INDEX

TO THE

AGRICULTURAL LEDGER

FOR THE YEARS

1900—1905.

CALCUTTA
OFFICE OF THE SUPERINTENDENT, GOVERNMENT PRINTING, INDIA.
1906.

CONTENTS.

NOTE.

To those who bind the *Agricultural Ledger* two alternatives are suggested; they may bind the issues of each year into an annual volume, or they may keep apart the Series into which it is divided.

These Series are as follows :—

I.—VEGETABLE PRODUCT SERIES.
II.—ANIMAL PRODUCT SERIES.
III.—MINERAL AND METALLIC SERIES.
IV.—AGRICULTURAL SERIES.
V.—INDUSTRIAL SERIES.
VI.—ENTOMOLOGICAL SERIES.
VII.—VETERINARY SERIES.
VIII.—FOREST SERIES.
IX.—MEDICAL AND CHEMICAL SERIES.
X.—IMPLEMENT AND MACHINERY SERIES.
XI.—CROP DISEASE AND PEST SERIES.
XIII.—MISCELLANEOUS SERIES.

For either purpose indexes will be published. The annual index will continue to appear year by year; the "serial" indexes will appear at wider intervals.

The annual index refers to the numbering which heads the pages: the numbering at the foot, which is consecutive in each Series, will be used in the serial indexes.

Public libraries and similar institutions are likely to find the plan of binding in annual volumes the more convenient one.

I. HENRY BURKILL,

Officiating Reporter on Economic Products to the Government of India.

ERRATA.

No. 2 (1905). Phaseolus lunatus.—Report on the Chemical Examination of the Beans, page 11, line 14 from bottom, for *pe-saulagu* read *pe-santagu*. However, the name *pe-santagu* does not properly belong to Phaseolus lunatus.

No. 3 (1905). Saltpetre.—Manufacture and Composition of Indian Saltpetre, page 18, line 12, *for* Schlossing *read* Schloesing.

It is also necessary to correct an error which has crept into the Serial Paging of the **Vegetable Product Series**, beginning with No. 1 of 1905, and which runs through Nos. 89, 90, 91, 92 of the Series, thus :—

	Present Serial Paging.	Correct Serial Paging.
Agricultural Ledger, 1905—No. 1 . .	231—240	1—10
,, ,, 2 . .	241—246	11—16
,, ,, 4 . .	247—268	17—38
,, ,, 5 . .	269—280	39—50

N.B.—With Agricultural Ledger No. 13 of 1904, was completed the first exam. of the Vegetable Product Series, comprising pages 1—554.

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1900—No. 16.

ODINA WODIER.

(GUM.)

[*Dictionary of Economic Products, Vol. V.*, O. 38-49.]

JINGAN GUM.

A Report by PROFESSOR WYNDHAM R. DUNSTAN, F.R.S., *Director of the Scientific and Technical Department of the Imperial Institute, on the chemical properties and commercial value of the Jingan Gum. To this has been added an abstract of reports on the tree that yields that gum, as furnished by Forest Officers. The present paper may thus be described as a revision of the Dictionary article on* **Odina Wodier.**

By his letter No. 286, dated 12th June 1895, **Mr. J. S. Gamble** submitted four gums, to the Reporter on Economic Products, for examination and report. These were forwarded to the Imperial Institute, and judging from **Professor Dunstan's** useful report on page 8, to which special attention is drawn, it would appear that of the four gums indicated, that of **Odina Wodier** or *Jingan*, is the most promising as an article of commerce.

The recent information to hand from Forest Officers regarding that tree may be said to confirm and, in some cases, amplify the particulars already known so that a review of the entire literature of **Odina Wodier** is likely to be found of interest to the public.

Odina Wodier, *Roxb.; Fl. Br. Ind., II., 29; Wight, Ic., t. 60; Ind. Kew., III., 328;* ANACARDIACEÆ.

Vern.—*Jingan, kiamil, kaimil, kimúl, kamlái, kasmala, ginyan, jhingan, mowen, mohin, moyen,* HIND.; *Jiol, bohar, jiyal,*

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lohar, bhadi, jír, jial, jival, ghadi, BENG.; *Dowka, dhoka,* KOL.; *Doka,* SANTAL; *Mooi, saripathri mooi, indrámai,* URIYA; *Hneingpyoing,* MAGH.; *Bara, dabdabbi, halloray,* NEPAL; *Kekeda,* KURKU; *Kaikra, gumpri, gharri,* GOND; *Jhingan, jingan, jibán, sindan, karalhí,* N.-W. P.; *Kiámil, kambal, batrín, kimlú, kemball, dhauntika, dila, kemal, koamla, sulambra, pichka, lidra, kamlai, kahmal, jingan,* PB.; *Gob,* RAJ.; *Simati, moya,* SIND.; *Gunja, monni, mageer, moyeen,* C. P.; *Shimti, ginyan, moya, kimul, moina, moi, simati, moja, shembat, molarda, gajel,* BOMB.; *Moi, moja, moye, shimat, munídi, shimti,* MAR.; *Wodier, wude, odiyamaram, odiamaram, otiyam, othiamaram, aunay-cauray,* TAM.; *Gumpini, gumpini banku,* the gum, *gumpani, gumpna, dumpini, dumpri, dumper, dampara, odai-manu, gumpena chettu,* TEL.; *Shimti, púnil, gojal, udi, suggipatte, shimli,* KAN.; *Nabé, nabési,* the gum, *knabe, knanbai, nabhai, nabhay, nabé-bin, knabé,* BURM.; *Jingini,* SANS.

References.—*Roxb., Fl. Ind., Ed. C.B.C., 336; Voigt. Hort. Sub. Cal., 275; Brandis, For. Fl., 123; Kurz, For. Fl. Burm., I., 321; Gamble, Man. Timb., 110; Dalz. and Gibs., Bomb. Fl., 51; Stewart, Pb. Pl., 46; La Maout and Decaisne, 363; Mason, Burma and Its People, 540, 774; Elliot, Fl. Andhr., 45, 65; Pharm. Ind., 60; Ainslie, Mat. Med. Ind., 486; O'Shanghnessy Beng. Dispens., 22; U. C. Dutt, Mat. Med. Hind., 301; Dymock, Mat. Med. W. Ind., 2nd Ed., 202; S. Arjun, Bomb. Drugs, 36, 207; Baden-Powell, Pb. Prod., 396, 397; Atkinson, Him. Dist., 308, 744; Econ. Prod., N.-W. P., Pt. I., 5; Lisboa, U. Pl. Bomb., 54, 242, 250, 278; Watson, Rep., 4, 22, 53, 55; Balfour, Cyclop., III., 8; Kew Off. Guide to Bot. Gardens and Arboretum, 37; Home Dept. Cor., 239; Burm. Gaz. I., 134, 137; Jour. Agri.-Hort. Soc., 1875, V., 75; For. Ad. Rept., Chutia Nagpur, 1885, 29; Gazetteers:—Mysore and Coorg, I., 52, 59; III., 28; Bombay, VIII., 11; XIII., 26; XV., 73; N.-W. P., I., 80; IV., lxx; Panjáb:—Rawalpindi, 15; Hoshiárpur, 11; Gurdáspur, 53; Shákpur, 69; Settlemt. Repts., Seonee, 10; Bhandára, 19; Nimar, 306; Betul, 127; Chhindwárá, 107; Manuals of Administration, Trichinopoly, 79; Madras, I., 362.*

Habitat.—A large deciduous tree, 40 to 50 feet in height, met with throughout the hotter parts of India from the Indus eastwards. It ascends in the South Himálayan tract to an altitude of 4,000 feet; is

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Jingan Gum. (*W. R. Yates.*)

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found also in Assam, Madras (chiefly in a cultivated state), and in Burma, the Andaman Islands, and Ceylon.

The following recently received particulars regarding the distribution of the tree may be here exhibited :—

North-West Provinces.—The tree is met with in the School Forest Circle.

Panjab.—Found abundantly in the Kangra Division. Wild and never cultivated it is principally associated with other miscellaneous trees in the scrub forests in which it forms one of the most conspicuous objects. It also occurs in the lower lying *chil* forests and the mixed forests on the main range up to about 3,000 feet. The tree grows in both dry and moist soils, but reaches its greatest size in valleys with a moist, deep soil—the wood in these situations is said, however, to be inferior. At the age of 30-40 years, when it is fit to be cut, the tree attains a height of 30-40 feet with girth 4-5 feet. It is leafless from November to February. Seasons of flowering and fruiting February-March and May-June. A report from the Forest Officer, Umballa District, states :—the Kalisar Reserve is the only forest in the Simla Division where the tree is found. It occurs scattered and not in any abundance. No particular care is taken to propagate the tree. It grows on the hot southerly slopes of the low hills, seldom reaching a height of more than 40-50 feet, or a girth of over 5-6 feet. The flowers appear in March-April when the tree is leafless, and the fruit ripens in June.

Madras.—Comparatively rare in the Ganjam District where it occurs wild on the lower slopes of the smaller hills and occasionally on the plains. Matures at the age of 50-60 years, attaining a height of 50 feet with girth 7 feet. Flowers in March-April, and fruits in June. Fairly common in the Bhadrachallam taluq, Godavari District, where it occurs in a wild state, both on the plains and at elevations up to (?)2,000 feet. It is estimated that the tree matures in about 30 years. Seasons of flowering and fruiting, February and March. In the Palamedu Range, Madura District, the tree occurs both wild and cultivated, though not abundantly. Sometimes propagated by means of cuttings. It thrives well in moist localities, attains a height of 40 feet with a girth of 6 to 8 feet, and is fit to cut at the age of 25 years. It flowers in April and bears seed in May. Not found in abundance in the Nellore District; is chiefly confined to the Veligondas and Zerragondas hills. Also occurs to some extent in Sreeharikota and

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Udayagiri. Ordinarily the tree luxuriates (in Sreeharikota) by the sides of ponds and lakes and in the vicinity of human habitations. It is reported not to thrive in the forests far from dwellings. No special care is taken to propagate it. Fit to cut at 20 years, the tree attains a height of 30 to 40 feet with a girth up to about 6 feet. Seasons of flowering and fruiting, March and April-May respectively. The District Forest' Officer, North Arcot, reports that the tree grows wild in the north of the district, but not in large numbers. It flourishes at elevations of 1,200-2,500 feet, attaining a height of about 25 feet with girth of 4-6 feet. In South Coimbatore the tree is here and there met with in the Udamalpet and Matupalayam Forest Ranges. It is also planted as an avenue tree on the Pokachi-Udamalpet Road, being usually raised from cuttings. In other places no special care is taken to propagate it. As a roadside tree it is not a success since it becomes quite leafless in the hot season. It grows wild in both dry and moist regions, reaching a height of 20-30 feet, with a girth sometimes as much as 8 feet. The tree flowers and fruits between May and July, and becomes fit for felling at the age of 20-25 years. It is reported to occur in the Tinnevelly District. From a report by the District Forest Officer, Trichinopoly, it is learned that the tree is found scattered in the plain and cultivated parts of the district. It does not grow wild but is generally propagated by cuttings. It flourishes in fertile and cultivated localities. The height to which it attains is from 50 to 70 feet, with a girth of from 5 to 12 feet. The tree is reported to be fit for cutting down at the age of 15 years. It flowers in May and fruits in June-July.

Burma.—Common throughout the Pegu Division where it grows wild and prefers low-lying situations. Average height 50-60 feet, but trees of 100 feet height and 9 feet 9 inches girth have been recorded. Usually the tree is not felled until it has reached a girth of 3-4 feet. The flowers appear in January and February; the fruits ripen in May and June. Fairly abundant in the Thayetmyo Division, growing wild in moist situations. Seasons of flowering and fruiting, December and January. Occurs plentifully all through the northern part of the Henzada-Thôngwa Division. The tree grows wild throughout the Henzada District. It flourishes in forest, at the foot of the hills, attaining a height of 30-40 feet with girth of 6 feet. Considered mature at the age of 35 years. The tree flowers in March and fruits

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April-May. Met with in the Lower Chindwin Division, but not to any considerable extent. Occurs wild on rather low ground. Has been known to grow to a height of 50-60 feet with girth 12 feet, but the average height is 35-40 feet and girth 5-6 feet. Regarded as mature at age of 15-20 years when a girth of 4-5 feet is attained. Seldom used. Seasons of flowering and fruiting end of May and July. From the Yaw Division it is learned that the tree is common in all the moister forests of the Division. Not cultivated, but grows wild; luxuriates on rather dry slopes in moderately moist forest. Attains a height of 70-80 feet or more and a girth of 4 feet 6 inches. It reaches an exploitable size at a very early age. The tree flowers in the hot weather and fruits about the end of May and June. Wild and very common in the Minbu Division. On good soil and situation attains a girth of 10 feet or more. From the Magwé Division it is reported to be fairly abundant in the forests outside the Reserve. Very scarce inside the Reserve, it grows wild in the level country outside, reaching a height of 40-70 feet with girth 3-6 feet. The tree is considered fit for felling at the age of about 20 years. The flowers and fruits are said to appear about April. Found almost everywhere in the dry mixed forests of the Mandalay Division up to about 3,000 feet elevation; the tree is, however, not plentiful. It occurs wild, prefers open jungle and appears to thrive best on stony soil. It attains a height of about 45 feet with a girth of over 6 feet. The tree flowers in February-March, but the seed does not ripen until 7 or 8 months later. Reported to be plentiful in the forests of the Pyinmana Sub-Division, Yamethin District, where it is associated with **Dipterocarpus tuberculatus, Shorea robusta, Pentacme Siamensis** and others. Grows wild mostly in "Indaing" forests attaining a height of 40-50 feet and girth of 6 to 8 feet. Seasons of flowering and fruiting, March and the hot weather. Fairly common in the Ruby Mines Division, Katha, where it occurs on the plain and low hills. Average height 40-60 feet. Flowers early in the year.

Andamans.—Met with as a small tree in fair abundance in the belts of dry deciduous forests of the islands. Of these forests Padauk (**Pterocarpus dalbergioides,** *Kurz*) is the principal species. The tree extends from sea-level to about 400 feet and attains a size of 8 feet in the girth breast high, and 35 feet in height.

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Properties and Uses.

GUM.

I.—Gum.—From wounds and cracks in the bark of this tree, at some seasons of the year, there issues a GUM, at first yellowish white in colour (*kanne-ki-gond*), which takes on a brownish tinge, and afterwards, if it falls to the ground, becomes blackish (*jingan-ki-gond*). It usually exudes in October and "occurs partly in tears of a yellowish tinge, partly in colourless, angular fragments which are full of fissures like those of gum-arabic. It has a disagreeable taste, is not astringent; about one-half is completely soluble in water; the remaining portion forms a slimy mucilage, but is not gelatinous" (*Dymock*). It is much used along with the gum of **Anogeissus latifolia** in calico-printing, and in Nepál as a paper-size. In Kumáon **Captain Campbell** states that it is mixed with lime in white-washing. In Burma, **Kurz** says, it is employed as the basis of an inferior varnish. The Brahmins of Bengal use it to stiffen their Brahminical strings.

The following recent provincial notes regarding the gum may be here recorded:—

Panjab.—The gum is very little used. It does not, so it is said, exude, naturally, but only on incision of the bark or as the result of an injury obtained chiefly during the rainy season. A full size tree is said to yield about ½ a seer (1 lb.) of gum per annum. The cost of collecting and landing at Railway station is estimated at about R50 per 100 lbs. A fair amount could be collected from the Division if required (*Kangra Division*). The gum is collected and sold in the bazars. It is used for adhesive purposes, in lime-washing and in calico-printing. It is, however, usually mixed with other gums, especially those of **Buchanania latifolia, Anogeissus latifolia,** and **Boswellia serrata.** The gum does not exude naturally from the tree but only in consequence of an injury. The method of tapping adopted locally is to cut a notch about 2 inches deep in the tree. The gum then exudes and hardens, when it is scraped off. The trees are notched in February-March, and the gum collected in May-June. It is hard and of a yellowish white colour, but that which exudes in the rains, and becomes mixed with water, is blackish. It is said that about 2 lbs. of gum can be obtained annually from one tree. The possible annual yield may be roughly stated at about 400 lbs. At present no regular trade exists, the gum being collected by the villagers in small quantities only. The price may be given as

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R12 per 100 lbs. landed at the nearest Railway station, *viz.*, Jagadu, 30 miles from Kalesár (*Kalesar Reserved Forest, Umbala District*).

Madras.—Not used either commercially or for domestic or medicinal purposes (*Ganjam District*). The gum is not collected. It exudes naturally from faults in the trunk. Trees that are quite sound yield no gum. The latter can be obtained in the hot season from March to May. A tree yields from two or three ounces to 2 lbs. of gum. The average would be about ½ a lb. A hundred pounds could be delivered at Rajahmundry at a cost of R3-12. This taluq could probably supply about 200 candies (1 candy = 200 lbs.) annually (*Bhadrachallum Sub-Division, Godaveri District*). Not collected or used. It is reported that in old and mature trees the gum exudes naturally and in others if the bark is injured. In mature trees gum exudes all the year round (*Madura District*). Gum is not systematically collected, but it is available in the bazars. Exudes only by injury—natural or artificial—by wear and tear of sun and rain or by cuts in the bark with an axe. Obtained in all seasons by injury, but considered to be most abundant in the cold and rainy season—August to February. A tree in good condition would probably yield 6 lbs. of gum yearly. In Sreeharikota the cost of carriage on 100 lbs. to the Buckingham Canal is estimated at six annas. The corresponding charge in the case of gum from Veligonda and Zerrakonda forests would be R3. About 70 lbs. of gum could be collected in Sreeharikota, but the production in other parts cannot be estimated. The gum is occasionally used for cloth-printing (*Nellore District*). The gum exudes naturally and also at times from wounds made in the bark by cattle graziers. No gum was obtainable from incisions made in September and October 1897: a quantity was found to have exuded naturally during February and March following (*North Arcot*). Not collected or used. The gum exudes by injury done to the bark (*South Coimbatore*). The gum is not collected or used. It is reported that the gum exudes in the rainy season, generally in consequence of some injury—by wounding the bark. The average yield per tree is estimated at not more than an ounce. (Trichinopoly.)

Cloth-printing.

Burma.—The gum is not collected or used. It does not exude naturally but from wounds. The gum is probably most plentiful in the rains (*Pegu Division*). Thought to exude only in consequence of some puncture. The latter may be the result of cuts, breakage of branches or small punctures made by birds. Unhealthy trees are reported to exude more than healthy ones. The gum is obtainable at

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any season (*Rangoon Division*). Not usually collected or used by the villagers. The gum seems to exude in consequence of some natural injury, and even then not at all times of the year (*Thayetmyo Division*). Not collected or used for any purpose. The gum exudes from wounds and cracks in the bark. It is obtainable from October to April (*Henzada-Thôngwa Division*). Not collected or used for any purpose by the Burmese. The gum exudes naturally (*Lower Chindwin Division*). Not collected or used. It is thought, however, that a considerable quantity could be obtained without difficulty (*Yaw Division*). The gum is not collected or used. It exudes naturally about the months of March and April. About 25 lbs. of gum may be got from a good sized tree in a year. This estimate is probably over the mark. The gum could be landed at the nearest steamer ghat 32 miles distant at from R3 to R4 per 100 lbs. (*Magwé Division*). Trifling quantities of the gum are collected for local consumption. There is no trade in the article. It is used for making an inferior kind of varnish. The gum exudes probably in consequence of some injury, but the tree is not wounded for the purpose. It is usually gathered after the close of the rains (*Mandalay Division*). Not collected or used locally. It exudes naturally during the rainy season (*Pyinmana Division*). Not used for any purpose (*Ruby Mines Division, Katha*).

Varnish.

Andamans.—The gum exudes from the bark naturally and is used by the Andamanese for keeping their fires alight. The gum is obtained at about the commencement of the dry season.

Report by* PROFESSOR WYNDHAM R. DUNSTAN, F.R.S., *Director of the Scientific and Technical Department of the Imperial Institute, on some Indian Gums.

"The gums which have been examined are described in a letter from Dr. George Watt to Mr. Royle, dated the 2nd June 1896, which enclosed a copy of a memorandum, No. 286, dated 29th June 1895, from Mr. Gamble, Conservator of Forests, School Circle, North-West Provinces and Oudh, on the subject. Mr. Gamble stated that the local demand for the following gums, which are procurable in the forests of the Saharanpur Division, is not very good, and that it would be advantageous if new and better markets could be found for such products. At present the supply is limited, but if new markets

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could be found, the supply of certain kinds, especially those of *Jingan* and *Pial*, could be greatly increased."

[The four gums contributed by Mr. Gamble and reported on by Professor Dunstan were as follows:—**Bauhinia retusa, Odina Wodier, Buchanania latifolia, and Boswellia serrata.** The present review deals with only the second of that series, and the passages in Professor Dunstan's Report that refer to the others will be excluded from the present paper.—*Ed.*]

Odina Wodier.

"The specimen consisted of small rounded tears and angular fragments with a few large irregular masses. The tears were opaque and fissured, the fragments, translucent, the gum had very little taste, and varied from white to yellowish-white in colour. The gum contained 12·3 per cent. of moisture and the ash in the dried gum amounted to 3·73 per cent. The gum was completely soluble in twice its weight of water, forming a rather thin mucilage, which possessed considerable adhesive power. The viscosity of the mucilage, compared with good gum arabic, is given below. The watery solution answered the ordinary tests for gum arabic, except that it had a marked reducing action on Fehling's solution, indicating the presence of a sugar. A solution made with boiling water and cooled, was unaffected by iodine, showing the absence of starch and similar constituents.

"***Comparative determinations of viscosity.***—The viscosity of the solutions yielded by these gums compared with that of a solution of the best gum arabic, was approximately determined by noting the time taken by 50 c. c. of a 10 per cent. solution to run from a burette fitted with a fine jet. . . . The following table gives the results obtained :—

	Strength.	Burette time in seconds.
Acacia Arabica (Gum arabic) .	10 per cent.	78
Odina Wodier (*Jingan*) .	10 „	58
Buchanania latifolia . .	10 „	184
Baukinia retusa . . .	5 „	200

"It appears from these results that a solution of the gum from **Odina Wodier** possesses about three-fourths of the viscosity of a similar solution of gum arabic.

"The only previously recorded examination of these gums seems to be that by Dr. Rideal in 1892 (*Journal of the Society of Chemical*

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Industry, Vol. II), who was furnished with small samples by Professor Pedler of Calcutta. Although it is evident from the preliminary results recorded by Dr. Rideal that the gums examined by him were the same in origin as those now under notice, it is obvious that their quality is different and usually inferior. It is important that attention should be paid in the future to the exportation of gum of uniform quality.

"Since the commercial value of the gums of the Acacia type must depend on other circumstances than those connected with their chemical properties, as, for example, colour, size, freedom from contamination with extraneous substances, etc., it was thought desirable to obtain the opinions of several of the best known London dealers in gums. They were each supplied with small representative samples of the three gums, and were asked to furnish a report on their probable commercial value. The four reports which have been received may be summarised as follow :—

"1. These brokers report that **Odina Wodier,** chiefly on account of its solubility, would be the most readily saleable. . . .

"2. The brokers report that there is on the English market a large quantity of all kinds of East Indian gums, which renders it very difficult to dispose of inferior qualities. The only sample which they consider would command a free market is that of **Odina Wodier.** . . **Odina Wodier** is compared with Cape gum, and, like it, might be used for preparing pale-coloured mucilages, and for mixing with gum acacia to reduce the cost of the latter. Its value is stated to be between 25*s*. and 30*s*. per hundredweight. These brokers remark that it is desirable, when introducing a new gum, to ship it in large quantities of not less than, say, 5 tons, as English consumers will not trouble to substitute new gums unless they are certain of obtaining a constant supply of average quality.

"3. The brokers report that all the samples are of inferior quality. **Odina Wodier,** which they remark has been carelessly collected and is largely mixed with earthy matter and wood, would fetch from 20*s*. to 25*s*. per hundredweight.

"4. **Odina Wodier** is the most valuable of the three samples submitted, but its appearance is much against it. If a constant supply could be obtained and if more care be taken in collecting it, it could probably be sold at from 30*s*. to 35*s*. per hundredweight.

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"It will be seen from these commercial reports that it would be worth while to pay some attention to the exportation of **Odina Wodier,** but it would evidently be necessary that greater care should be taken in the collection of the gum, and that the inclusion of extraneous matter should be avoided. It would probably be desirable to pick out the better pieces which are nearly free from colour, and send them as a separate consignment as first quality, the coloured and contaminated fragments being included in a separate consignment of second quality. One firm of brokers who reported on the samples, offered to take charge and dispose of any consignments of these gums which may be sent to this country."

DYE AND TAN.

II.—Dye and Tan.—The BARK of the tree furnishes a small amount of brownish-red colouring matter, which produces on tasar silk a golden or pale brown tint similar to that obtained from *lodh* bark **(Symplocos racemosa)** (*Wardle*). It is also used in tanning.

Madras.—The bark is employed for tanning purposes (*Nellore*).

Burma.—The bark is used for making boats (*Thayetmyo Division*). The bark being thick and fibrous is employed instead of hides to protect the elephant's back from the weight of the dragging chains (*Minbu Division*). The bark is said to be mixed with **Acacia Catechu** in Cutch boiling, but this requires confirmation (*Pyinmana Division*).

FIBRE.

III.—Fibre.—The BARK yields a good or tough coarse cordage fibre.

Madras.—The bark affords a fibre (*Nellore District*).

Burma.—The bark fibre is used in connection with ploughs and elephant gear (*Thayetmyo Division*).

MEDICINE.

IV.—Medicine.—The BARK is very astringent, and although not officinal is described in the *Pharmacopœia of India.* A decoction is said to be useful as a local application in cutaneous eruptions and obstinate ulceration, and to form an excellent astringent gargle. **Ainslie,** who gives a similar account of its properties, remarks :—" The bark powdered in combination with *margosa* oil is considered by the *Vytians* a valuable application for old and obstinate ulcers." The GUM, beaten up with cocoanut milk, is applied to sprains and bruises, and the LEAVES boiled in oil are used for a similar purpose. It is given internally in asthma, and as a cordial to women. Externally it forms

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MEDICINE.

the basis of many of the plasters employed for rheumatism. In Taylor's *Topography of Dacca* mention is made of a medicinal use of this tree not referred to elsewhere. He says that the JUICE of the green branches, in a dose of four ounces mixed with two ounces of tamarinds, is given as an emetic in cases of coma or insensibility produced by opium or other narcotics.

Panjab.—The gum is used in native medicine (*Kangra*).

Madras.—The gum is stated to be applied medicinally to sprains and bruises, after being beaten up with cocoanut milk. Bark and gum are demulcent and tonic, respectively. The pounded bark boiled in or mixed with oil is applied to ulcers and wounds. The bark forms a gargle and is used for decoction (*Nellore District*). The bark is used for skin eruptions and for local injuries, such as wounds and bruises. It is beaten with a stone and then applied to the affected part (*Madura District*). The JUICE of the bark is said to be administered to children as a tonic (*South Coimbatore*). Pounded up with old rags it is said to be used as a plaster for wounds (*Trichinopoly*).

Burma.—The juice of the bark is applied to swellings (*Pegu Division*). The bark is boiled in water and the decoction employed for dressing sores (*Pegu Circle, Rangoon*). A decoction of the bark is used for toothache (*Thayetmyo Division*). The bruised bark is applied by villagers to sores (*Mandalay Division*).

The leaves are used for all local swellings and pains of the body. They are first boiled and then applied (*Madura District*). The leaves after being pounded are applied to sores (*Pegu Division*). They are used as medicine for children (*Thayetmyo Division*).

FODDER.

V.—Fodder.—The LEAVES and young SHOOTS afford fodder for cattle. In some places (Madras, Oudh, etc.) it is pollarded to supply fodder for elephants (*Gamble*).

Panjab.—The leaves along with those of other trees are extensively lopped for grazing purposes by shepherds and others (*Kangra Division*).

Madras.—It is reported that the bark is given to elephants for the purpose of improving their digestion. Leaves are used for fodder (*Nellore District*).

Burma.—Leaves or branches are readily eaten by elephants (*Pegu Circle*).

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Jingan Gum. (*W. R. Yates.*) ODINA Wodier.

It is said that sometimes silk-worms are fed on the leaves, but only very seldom (*Lower Chindwin Division*). **Silk-worms.**

Lac forms on the twigs and some (not a large proportion) of the stick-lac brought down from the Shan States is *hnabe* lac (*Mandalay Division*). **Lac Insect.**

VI.—Structure of the Wood.—The sapwood is large in amount and very subject to the attack of worms; the heartwood when freshly cut is light red, but becomes reddish brown on exposure. It is moderately hard, close-grained, seasons well, and does not warp, but is not very durable (*Gamble*). It is, however, not liable to be attacked by white-ants (*Gazetteer, Mysore and Coorg*). Average weight about 58 lbs. the cubic foot. **TIMBER.**

The following passages may be here usefully recorded from the recent correspondence that has taken place on this subject:

Panjab.—The timber is of inferior quality; only the heartwood is used. There is very little market for it. Occasionally exported in small quantities to the plains. The price locally is R1 per tree, or for local use 4 annas. Planks of the timber are said to warp considerably if not properly seasoned. Occasionally brought and taken by river to Ferozepur and elsewhere where it is sold to Zamindars, so it is stated, at four annas per *karri* of 2 cubic feet (nearly) (*Kangra Division*). The sapwood is whitish, and the heartwood reddish brown. It is hard and heavy. It is not attacked by white-ants. Better species being readily obtainable, there is no trade in the timber (*Kalesar Reserve, Umbala*).

Madras.—Only a very small local trade. The best only fetches about annas 3½ per cubic foot in the market (*Ganjam District*). The timber is not at all appreciated owing to the abundance of better kinds. It is said to be notorious for its want of strength and durability: never used for construction or other work, as it is soft wooded by nature (*Madura District*). Not used for building purposes (*Nellore District*). Useless for building construction (*North Arcot District*). The wood is very light and white in colour. No trade exists (*South Coimbatore*). The timber is not used. Not strong nor durable and is liable to attack by white-ants (*Trichinopoly District*).

Burma.—Sapwood rather light, and of a whitish colour, turning pale brown: heartwood heavier, close-grained, of a reddish brown colour. Weight per cubic foot 65 lbs. (*Kurz*). It is very durable. Some house posts here—still in good condition clean of sapwood

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ODINA Wodier.

Jingan Gum.

Domestic.

and having a girth of 2 feet 3 inches to 3 feet 4 inches—have been in use over 30 years. When dry it floats. Trees of large girth are rare in these forests, but logs below 4 feet 6 inches in girth could be supplied in considerable numbers. There is no special trade in the timber. It is sold in lots mixed with other less valuable woods. The rate varies considerably from R600 to R1,000 per 100 logs averaging 6 feet to 7 feet 6 inches girth and 18 feet length (*Pegu Division*). There is no trade in the timber (*Pegu Circle*). The timber rots very quickly in the ground or if exposed to the weather. It is used only when no other can be obtained (*Thayetmyo Division*). Not regarded as very durable. A large quantity could be supplied if wanted. The cost of delivery on the river bank would be about R3 to R4 per log. There is no trade in the timber at present (*Henzada-Thôngwa Division*). The timber is said to be of rather poor quality. Scarcely any trade in it (*Lower Chindwin Division*). The supply greatly exceeds the demand. There is no trade (*Yaw Division*). The sapwood is said to be subject to attacks of white-ants (*Minbu Division*). Very little used locally as the wood is said to be too soft. There is no trade in it (*Magwé Division*). The wood is hard and is considered imperishable in the ground as boundary posts. It fetches from R12-8 to R18 per ton in Mandalay where over 50 tons are sold annually (*Mandalay Division*). Very seldom used and no local trade in the timber (*Yamethin District*). The wood does not seem to be used nor is there any trade in it (*Ruby Mines Division, Katha*).

VII.—Domestic Uses.—The wood is used for a variety of purposes. Spear shafts, scabbards, wheel spokes, cattle yokes, oil presses, and rice pounders are made of it. It was tried for sleepers on the Madras and on the Oudh and Rohilkhand Railways, but did not succeed. Kurz recommends it as suitable for cabinet making; but no trial of the wood for that purpose has apparently as yet been made.

Panjab.—The heartwood is used for small *karris*, doors, planks etc. (*Kangra Division*). Sometimes used by the villagers for making, clod crushers. It is of course used as fuel as are all the other species found in the mixed forest of this district (*Kalesar Reserve, Umbala*).

Madras.—Chiefly used for planking (*Ganjam District*). Yokes are sometimes made from the timber owing to its lightness (*Madura*

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District). Used for fuel and various agricultural implements, such as yokes, etc. (*Nellore District*). Employed for the making of bedsteads, posts for fences, and water-lifts (*Trichinopoly District*).

Burma.—Chiefly used in house building as posts, beams, rafters, etc., and as handles for *dahs* (*Pegu Division*). Used locally for house building (*Henzada-Thôngwa Division*). The timber is said to be of rather poor quality. The chief use to which it is put is in making Burmese drums. Also occasionally used for coffins (*Lower Chindwin Division*). Chiefly employed for handles of *dahs* and *dalwés* (*Yaw Division*). Sometimes used in agriculture for rollers to break up clods of earth (*Minbu Division*). Now and then used for house planking, making bedsteads, etc. (*Magwe Division*). Used for sandals, *dah* scabbards, rice mortars and oil presses (*Mandalay Division*). Not used except very occasionally for oil-presses (*Yamethin District*).

It will thus be seen that the very greatest difference of opinion prevails regarding the timber of this tree, but upon the whole it is not held in high esteem.

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G. I. C. P. O.—No. 2563 R

THE

AGRICULTURAL LEDGER.

1900—No. 18.

BŒHMERIA NIVEA.

[*Dictionary of Economic Products, Vol. I.*, B. 576-606, *also Vol. VI. Pt. I.* (*Rhea*) R. 172-213.]

RHEA (RIHA) OR CHINA-GRASS.

[Corr]espondence between MESSRS. THIRKELL & CO., *London, and the Imperial Institute on the subject of Rhea Ribbons.*

With a view to make Messrs. Thirkell & Co.'s offer as widely known as possible, the appended correspondence is published as a supplement to *The Agricultural Ledger* No. 15 of 1898.

Those who are desirous of instituting experiments in the production of Rhea ribbons may communicate, through the Reporter on Economic Products or direct, with Messrs. Thirkell & Co., as they think best.

No. I. S. C. 102-99, dated London, S. W., the 17th November 1899.

From— J. R. Royle, Esq., C.I.E., ***Secretary and Curator, Indian Section, Imperial Institute, S. W.,***

To—The Reporter on Economic Products to the Government of India.

I have the honour to forward herewith a copy of a letter just received from Messrs. Thirkell & Co., stating that they are prepared to take at about £15 per ton, all the Rhea ribbons that India can produce for some years to come, and saying that they prefer the fibre in the ribbon stage instead of having it further prepared in India. If required, they are able to supply decorticators at about £40, which are capable of preparing about 10 cwt. per day.

Enclosure (A), dated 16th November 1899.

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Rhea (Riha) or China-Grass.

RHEA FIBRE.

In explanation of their reference to previous correspondence, I enclose also a copy of the firm's report on a sample of Rhea ribbon No. 4259, which was received by me a year ago from Messrs. R. G. Shaw & Co., of 88, Bishopsgate Street Within, and said to have been produced on their Assam Estates.

Enclosure (B), dated 16th November 1898.

I am informed that the present is a new demand which is likely to be permanent and which will not interfere with previous uses of the fibre, and I shall be glad to hear at an early date if you think it likely that India will do anything to meet the demand.

ENCLOSURE A.

Dated the 16th November 1899.

From—Messrs. Thirkell & Co., *155, Fenchurch Street, London,*

To—J. R. Royle, Esq., C.I.E., *Secretary and Curator, Indian Section, Imperial Institute,*

Referring to our Report on No. 4259, Rhea Ribbons, Assam, dated 16th November 1898, which we beg to confirm.

Will you please make it known to whom it may concern that we are prepared to contract for all the Rhea Ribbons that can be grown in India for years to come at about the price named £15 per ton.

A new use has been found for Rhea for which very large quantities are required—we have orders to purchase all we can get at moderate prices. You may confidently recommend the Government to foster the cultivation as much as possible.

We prefer the Rhea in the bark, that is, what the trade call "Rhea Ribbons," the crudest form in which the Rhea can be shipped—thus obviating any large initial outlay for plant and machines. We can supply decorticators to pass about 10 cwt. per day at about £40 each—the Rhea can be decorticated on the field and requires only to be thoroughly dried and may be press-packed as tightly as jute.

You may refer to us any one wishing to grow, or ship Rhea, and we will satisfy him of our ability to take all he can sell. May we ask you to pass this information on to other Sections of the Institute, so that the growth of Rhea may be increased in all countries. We want, and shall want for some years to come, all the Rhea the world can produce, at moderate prices. We may add, the buying of Rhea for this new purpose will be solely in the hands of the writer.

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ENCLOSURE B.

Dated the 16th November 1898.

From—Messrs. Thirkell & Co., *155, Fenchurch Street, E. C., London,*
To—J. R. Royle, Esq., C.I.E., *Secretary and Curator, Indian Section, Imperial Institute, S. W.*

We have examined your sample No. 4259, Rhea Ribbon, from Assam—this sample is of fair length, strong and apparently of good quality. We would recommend your correspondents to send to us direct a small quantity in first instance free of charge to enable us to get the fibre tried by manufacturers. If this sample parcel works out satisfactorily, orders will probably follow—the present nominal value is £15 per ton with a downward tendency. Care must be taken to send fibre only from stems of mature growth, as even in length as possible—trouble has recently arisen with parcels sent long and short together. It is found that the short *immature* fibre not only much more wasteful, that is, the ribbons yield much less fibre, but also the fibre obtained will not produce the same quality of yarn, and is in consequence of very low value. We would also repeat, that so soon as sufficient Rhea can be produced, it will probably be desirable to prepare the same on the spot, that is, to bring it to the condition of raw "China" grass. Those who were so strong a few months back in their opinion that they preferred Rhea in the Ribbon, seem to be backing down a little.

After the foregoing had been in type, Mr. Royle wrote under date 3rd August 1900, I.S.C. 124, as follows:—

With reference to your letters Nos. 2576-75 of 28th June and 2739-78 and 2740-75 of 12th July, I have ascertained from Messrs. Thirkell & Co., that they have no Agents in India.

They tell me that the question of Decorticators generally does not even yet appear to be quite satisfactorily settled, but that they hope very shortly now to be able to recommend a good machine at about the price of £40.

In the meantime they consider Faure's (of which I enclose a prospectus) to be about the best, but it turns out not "strips" but fibre. In many districts, however, they believe that the Ribbons can be produced without machinery by merely stripping the stems by hand labour.

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Rhea (Riha) or China-Grass.

RHEA. DECORTICATORS.

Faure's decorticator requires about one-Horse power to drive it; the power can be provided by manual labour, but, at the high speeds, it is usually not satisfactory. If bullocks are used there is the disadvantage of frequent stoppings and starting, which throws the machines out of gear.

The price of £15 per ton *c. i. f.* quoted by **Messrs. Thirkell** in November last means delivered in London; they sold some at this price quite recently.

They now inform me that the large demand which they anticipated last year is still a matter of the future, but the big buyers now again inform them that they hope *very shortly* to be able to give orders and credits for a regular supply.

Apart from this, they consider that the cessation of shipments from China, and the absence of stocks in Europe generally, justify them in maintaining that there will be a large demand for Rhea before the cultivators can produce it in sufficient quantities.

Any further information shall be forwarded as soon as recei[illegible]

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G. I. C. P. O.—No. 197 R. & A.—5-11-1900.—2,230—W. B. G.

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AGENTS.

In London.

Messrs. E. A. Arnold, 37, Bedford Street, Strand, W. C.

Messrs. Constable & Co., 2, Whitehall Gardens, S. W.

Messrs. Sampson Low, Marston & Co., St Dunstan's House, Fetter Lane, E. C.

Messrs. P. S. King & Son, 204, Great Smith Street, Westminster, S. W.

Messrs. Luzac & Co., 46, Great Russel Street, W. C.

Messrs. Kegan Paul Trench, Trübner & Co., Charing Cross Road, W. C.

Mr. B. Alfred Quaritch, 15, Piccadilly, W.

Messrs. Williams and Norgate, Oxford.

" Deighton Bell & Co., Cambridge.

On the Continent.

Messrs. R. Friedländer & Sohn, Carlstrasse, 11, Berlin, N. W.

Otto Harrassowitz, Esq., Leipzig.

Karl W. Hiersemann, Esq., Leipzig.

Ernest Leroux, Esq., 28, Rue Bonaparte, Paris.

Martinus Nijhoff, Esq., The Hague.

In India.

Messrs. Thacker, Spink & Co., Calcutta and Simla.

Messrs. Newman & Co., Calcutta.

" Thacker & Co, Ld, Bombay.

" Higginbotham & Co., Madras.

Superintendent, American Baptist Mission Press, Rangoon.

E. Seymour Hale, Esq., Fort, Bombay.

Rai Sahib M. Golab Singh & Sons, Mufid-I- Am Press, Lahore.

Messrs. A. J. Combridge & Co., Bombay.

(Agricultural Series, No. 33.)
(Fodders.)

THE AGRICULTURAL LEDGER.

1901—No. 1.

PASPALUM DILATATUM.

[*Dictionary of Economic Products, Vol. V.*, Pat. I., P. 331a.]

A NEW FODDER GRASS FOR INDIA:

Being information collected in the Office of the Reporter on Economic Products

Interest has lately been aroused in the fodder plant known to botanists as **Paspalum dilatatum**, *Poir*. The present accordingly seems a fitting opportunity to bring together in a convenient form the information on this subject which at present exists in the Office of the Reporter on Economic Products.

The late Baron Ferd. von Mueller, K.C.M.G., etc., in his work *Select Extra-Tropical Plants*, page 218, gives the following description of the plant:—"Extra-tropical, South America. Perennial, of excellent quality for fodder. Mr. Bacchus found it hardy in Victoria up to a height of 2,000 feet. It grew in New South Wales, after drought was followed by heavy rains, 4½ feet in little more than two months. It is closely allied to the Mexican **P. virgatum**, *L.*, introduced into Australia like many other fodder grasses by the writer."

An interesting article on **Paspalum dilatatum** by Mr. C. Sargeant recently appeared in *The Melbourne Leader*. The paper was subsequently reprinted by *Indian Gardening* in its issue of 27th April 1899, and is here given in full:—

"That large and fertile district in Gippsland, known as the scrub country is rapidly being reclaimed; but the conversion of these regions into valuable grazing and agricultural farms has not been easily accomplished. Very large sums of money have been lost by the early

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PASPALUM dilatatum.

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pioneers in finding out the most suitable grass to sow. At first rye grass and white clover [were tried], but the results were distinctly not favourable. The grass grew well enough, but could not resist the caterpillars. Then a fresh start was made with cocksfoot, which proved an excellent grass, but failed in its turf-forming capacity. No matter how thickly it was sown, it has a strong tendency to thin out and become tussocky. Thus the soil becomes too much exposed, with injury to the pastures during hot weather. The cocksfoot, being a shallow-rooted grass, suffers much from drought, and, further, is peculiarly liable to the ravages of the grasshoppers. Nothing can be said against the cocksfoot as a fattening grass, the finest lambs that enter the Melbourne market being from cocksfoot and clover pastures; while cows fed on it give excellent milking results. If this grass would only form a turf nothing could be better.

"At the beginning of last year *The Leader* drew attention to a new grass—**Paspalum dilatatum**—that had been cultivated with much success by the Agricultural Department of New South Wales. Being much impressed with *The Leader* statements, I at once set about obtaining some seed for testing, and the results, so far, are most satisfactory; so much so, that I have come to the conclusion that the introduction of this grass into the colony for the purpose of fodder and pasture is most desirable. While endeavouring to induce the farmers of this locality to look upon this plant as a grass destined to supplant the cocksfoot as the primary grass in our pastures, the contention was met with that the grass already existed in the district, and that it was a weed. Being satisfied that this was a mistake, and that the whole question was of too important a character to neglect, I determined to undertake a journey to New South Wales for the express purpose of examining and investigating the grass in the districts where it is stated to be successfully established.

"This necessitated a special visit to the north-eastern corner of New South Wales, where is situated the rising district of Wollongbar, on the Richmond River, a locality that is destined to become one of the most important centres of production in that colony. About ten miles beyond Ballina, the first port of call, the country begins to rise to about 400 or 500 feet above the sea. This country, which was originally covered with timber and dense jungle, has been, and is still being, dealt with in precisely the same manner as the scrub country of Gippsland, the soil and the general aspect being in all

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points very similar. Wollongbar has lately come into prominence on account of the attention paid to the cultivation of artificial grasses, and foremost among those who have devoted their attention to this industry is Mr. H. Morton Williams, of "Florida," Wollongbar. Mr. Williams has been remarkably successful with the cultivation of the **Paspalum dilatatum** which, if appearance, growth, quality, and general results are anything to go by, certainly promises to become the queen of grasses for the dairy farmer and graziers generally. This grass is indigenous to Ceylon, and was first brought under the notice of Australians by the late Baron von Mueller, who strongly recommended it on account of its high nutritious qualities, and its drought-resisting properties, on which he laid great stress. Like many other things, very little notice was taken of the grass at the time. If any attempts were made to cultivate it, very little was heard of it. The first to introduce the seed into the Richmond River district was Mr. Edward Secombe, who procured a small parcel and succeeded in propagating it. No seed at the time could be obtained under 10*s.* to 12*s.* per lb. Mr. Secombe's experiments at once attracted the attention of Mr. Williams, who determined to give it a trial. Mr. Williams' holding consists of 100 acres, 60 of which is cleaned in the usual way, that is, by burning the cut scrub, and then burning off the logs. Of the 60 acres, 7 acres are occupied with garden, orchard, stockyards and flats for testing seeds, leaving 53 acres under grass. Much of this contains large bare patches where logs have been burnt off, so that, at the outside, there are not more than 50 acres. And since last September 7 acres out of that have been continually shut up for seed purposes. Mr. Williams states that in the first instance he sowed **Paspalum dilatatum**, cocksfoot, rye grass, timothy, couch grass, alsyke and white clovers. In addition to the **Paspalum** there are only small patches of cocksfoot and rye grass left. The **Paspalum** is asserting itself and gaining possession of the ground from which the other grasses have vanished. Having spent two days on the farms, and closely observed everything, I can from actual observation bear out all Mr. Williams' statements. He and others affirmed that the district was suffering from a four-months' drought, from October to the end of January, therefore it could not be said that things were under their best aspect.

NEW SOUTH WALES.

Success obtained.

"As showing the carrying capabilities of the **Paspalum**, the number of stock noted on the farm were 34 milk cows, 22 head

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young stock, ranging from 12 months to 2 years old, 1 bull and 6 horses, making a total of 63 head. The whole of the stock were in excellent condition, and, as a rule, their condition was better than that of cattle fed on other grasses. A feature of the farm is the number of small paddocks into which it is divided, and the process of subdivision is still being carried out. So rapid and continuous is the growth of the grass—assuming that it has a reasonable amount of rain—that the soundness of the principal of closing a paddock for a few weeks is fully demonstrated in the case of this remarkable pasture plant. It seems to possess exceptional vitality, together with sound constitution, and grows with great rapidity after a fall of rain. It should be noted that the whole of the grass seed on the farm was sown on the surface after the scrub had been burnt, and from a sample that was dug up for inspection I noticed that it presented a dense mass of fibrous roots, some of which were over 12 inches in length, showing that it grows no less vigorously downward than upward. In deeply cultivated land it is a veritable deep sinker, and a grass that, if given an opportunity, is thoroughly capable of looking after its own existence. As a frost-resisting grass I was informed that when the sugarcane was entirely blighted the **Paspalum** only showed very slight signs of having been affected. Cows when turned in upon it from other pastures, soon show an improvement, and an increased yield of milk. Mr. Williams, who sends his cream to the local creamery, furnished me with the average test for each month for the past year, which may be looked upon as a good yield, considering that the cows are purely a scratch lot, picked up in the sale yards, and in no way selected :—For January 3·7, February 3·7, March 3·8, April 3·8, May 4·1, June 4·3, July 4·1, August 4·0, September 3·7, October 3·6, November 3·5, December 3·6. As to the quality of the grass when converted into hay, subjoined is an analysis made by Mr. F. B. Guthrie and supplied by the Wollongbar Experimental Farm :—Moisture 10·55 ; total albuminoids, 10·31 ; soluble albuminoids, 1·38 ; insoluble albuminoids, 8·93 ; digestive fibre, 29·96 ; woody fibre, 27·95 ; total ash, 6·37 ; soluble ash, 4·32 ; insoluble ash (by difference), 2·05 ; amide compounds, 14·86. Total 100·00.

Results of analysis.

"From the foregoing it will be seen that the **Paspalum** is a valuable fodder plant as well as a pasture grass and worth the attention of all who may have land suitable to its growth. Where it will not grow it is difficult to say. It may be accepted that, provided it can obtain

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PASPALUM dilatatum.

NEW SOUTH WALES.

sufficient moisture, it will grow anywhere. It has been proved to grow in sand ; also some planted near salt water, and inundated with it, was none the worse for the immersion. The grass is certainly of most nutritious and succulent quality, and for an artificial grass, as already stated, it possesses wonderful vigour. It sheds its seed twice a year, and when the seed stems are in full bloom reaches as high as 5 feet, fresh stems still shooting from the crown in various stages of growth. My own experimental plot in Gippsland has plants now with stems reaching to the height of 4 feet 6 inches, and at the same time new shoots are rising from the crown. It is quite as strong and healthy-looking as that growing at Wollongbar, and its general bearing indicates that it has come to stay. Those who are in a position to speak authoritatively at Wollongbar, state most positively that it will carry a cow to the acre at the worst. Mr. Campbell, Inspector of experimental stations in New South Wales, is of opinion that its carrying capabilities would amount to an average of a cow and a half to the acre. Victorian dairy farmers will, however, no doubt be well satisfied with grass that will carry one cow to the acre. In this connection it may be reasonable to expect that in temperate Victoria during the winter months there may be a longer period of dormancy than in the sub-tropical district of the Richmond River. Experiment may show that such is the case on the south side of the Dividing Range in Victoria; but on the north side, specially in the Goulburn Valley and similar districts, where the winter is milder, the autumn growth may be prolonged and the spring growth earlier, especially if there is provision for flooding with water when required. It must be borne in mind that subdivision will be the keystone of success in dealing with this grass. The experience at Wollongbar is that when a paddock is shut up for a few weeks, the grass at once starts to grow and recovers itself rapidly. With respect to the permanency of the **Paspalum**, Mr. Williams has a small paddock that he laid down four years ago, which presents a solid turf of green verdure. There is not a speck of the soil to be seen. The sight of this paddock is enough to convince the most sceptical as to the value of the grass. Owing to its capacity for forming a strong turf it will no doubt do much in keeping down weeds, and it may in a great measure successfully resist the bracken fern.

"Like all artificial grasses, it may after a time be necessary to plough it up and re-plant. Of course the grass being quite new,

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experience will have to be gained as to its proper treatment. There are two essentials to ensure the seed germinating, *viz.*, heat and moisture. If a reasonable amount of heat is not obtained, the seed may be dormant for some time. In any case it must not be expected that the whole of the seed sown will germinate for a certain proportion is barren. In laying down a pasture, from 5 lbs. to 8 lbs. of seed is necessary, but as little as 2 lbs. may be sown. In that case, when the grass reaches the seeding stage, it will be necessary to close the paddock to allow of the shedding of the seed. By that means the paddock will become fully grassed. To sow such a small quantity of seed, in order to obtain an equal distribution, it requires to be thoroughly mixed with a quantity of sawdust.

"The fame of the **Paspalum** has reached the other colonies, including New Zealand. Orders for the seed are coming from all parts to Wollongbar. For the purpose of raising a pasture, roots of the grass may be planted. The seed of the grass is difficult to save, owing to its not all ripening at once. As a consequence, it entails a great amount of time and labour in collecting it. There is no reason why the grass should not thrive as well in Victoria as it does at Wollongbar, except, perhaps, that there may be a greater deadness in the winter, for which an allowance may be made by reducing the carrying capacity. Any one who is in a position to run 100 cows may regard himself as thoroughly independent, and this, according to the New South Wales proven experience, with **Paspalum**, handled as described in this article, can be done on 100 acres of reasonably good land."

The following passages, taken from the Report of a meeting of the Agri.-Horticultural Society of India held on 13th December 1899, appeared in *Indian Gardening* of the 21st idem.

"In connection with the reference made by the Department of Land Records and Agriculture, Bengal, in August last, **Mr. E. C. Whitehead** sends the following:—A report on a new fodder plant **(Paspalum dilatatum)** which can be grown with profitable results on all sandy wastes, by **Mr. A. Crawford**, the dairy expert of the Department of Agriculture, Perth, Western Australia, is published in the Perth *Western Mail* of the 26th May last. The plant will, I think, prove an inestimable boon to us in this country, for millions of acres that are now to all intents practically useless would become valuable grazing properties. The fodder or grass, **Paspalum**

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WESTERN AUSTRALIA.

dilatatum, will thrive even in the poorest soils. "At the quarantine station at Subiaco, two-and-a-half years ago at the beginning of summer it was planted in the poorest sandy soil with no manure and no attention. It grew well all the summer, and at the end it was found that it had put down its root 18 inches in the sand, and it was impossible to pull it up. It grew about 18 inches in height and kept growing the whole summer. Last year it was tried at Drakesbrook in good soil, but planted very late. The roots have not gone down so deep as in the sand, but they are strong and have a fine hold of the ground. The grass grew over 2 feet high, although it was planted just at the beginning of the summer, and had very little rain to give it a fair start. I planted it at Claremont in a better class of sandy soil, without manure, and, watered, it grew 3 feet 2 inches high in three months. I then cut it, and in 6 weeks it was over 2 feet high again. It had no rain or watering from the time of cutting. Some which I planted in the same kind of sand and did not water, grew 2 feet 9 inches, and after cutting, and still without water, it grew 2 feet 10 inches, and was quite green at the end of the summer. Some sown in manured sandy soil and watered regularly, did not grow nearly as high, but threw out more leaves and was inclined to become tussocky. In all cases at the two experimental stations and at Claremont, it kept green and grew right to the end of the summer."

Mr. G. M. McKeown, Manager of the Richmond River Experimental Station, New South Wales, writes thus about it :—"It is probably the best fodder plant or pasture grass yet introduced into this district, resisting both heat and cold, and yielding enormous quantities of fodder; much liked by stock, and shown by analysis to be of excellent quality. Plants in drills 18 inches by 6 inches apart quickly reached 5 feet in height, a test cutting giving 13 tons 3 cwt. to the acre. From a seed plot sown on the 28th September in sub-soil land a second cutting was obtained on the 3rd June in the following year, weighing at the rate of 19 tons 4 cwt. to the acre. Subsequent cuttings after saving the seed yielded over 14 tons to the acre. In deeply worked land at least three heavy cuttings may be obtained in the season. In all seasons good pasture may be obtained from this grass, if not overstocked, and once established, it stands well the grazing and trampling of stock."

Mr. H. Martin Williams of Wollongbar, New South Wales, remarks :—"Four years ago I sowed my first seed-bed, and my farm

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PASPALUM dilatatum.

A New Fodder Grass for India.

EXPERIMENTAL CULTIVATION.

is now practically sown with **Paspalum dilatatum**, and the more I see of it the more I like it. Of course I have mixed other grasses with it, but the **Paspalum** is the basis of the pasture. It has proved itself a mainstay, *growing vigorously when the fierce heat had parched up every other grass. It stands drought well,* and frosts do not kill it, and I have even cut it down and run a fire over it, and after this severe treatment it has grown as vigorously as ever. Its feeding qualities for dairying are undoubted. The quantity of seed to sow an acre is 5 lbs. to 8 lbs.

Mr. Sergeant, of Victoria, observes that he visited a farm consisting of 100 acres, whereon 60 acres are cleared and of that area 7 acres are taken up with garden, buildings, etc., leaving 53 acres under grass **(Paspalum dilatatum)** and other grasses. On this at the end of four months' drought, from October to the end of January, all the other grasses had disappeared, and yet it was carrying the following stock:—34 milk cows, 22 head of young stock from 12 months to 2 years old, 1 bull and 6 horses, making a total of 63 head. The farm was sub-divided into small paddocks, and the stock frequently shifted from one to the other. Mr. Crawford, after giving an analysis of hay made from **Paspalum dilatatum** by Mr. Guthrie, continues:—"This hay compares very favourably with ordinary hay, containing a large proportion of digestible and nourishing material. The best time for sowing is from July to September. The seed cost about 7*s*. per lb. A seed-bed could be sown and the plants divided and planted out later in the spring."

Conf. p. 4.

It is understood that this grass **(Paspalum dilatatum)** has been tried recently in Tirhoot with some success. Bullocks are reported to be fond of the grass which in good soil runs to 4 feet. It is also believed to flourish on Usar or Alkali lands.

It is not improbable that in the near future the experiments made by private individuals and others with this grass may lead to useful results. At present there is a scarcity of seed which has to be obtained from Australia and America.

Under the heading "The Fodder of the Future," the *Madras Mail* reproduces the following particulars in its issue of the 8th November 1900:—

"Messrs. Law Somner & Co., 139-141, Swanston Street, Melbourne, Victoria, Australia, who are now in a position to supply seeds of

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A New Fodder Grass for India.

PASPALUM dilatatum.

Paspalum dilatatum at 5*s.* 6*d.* a pound, postage, etc., extra, write as follows to the Secretary, Agri.-Horticultural Society of India: There can be no question as to **Paspalum dilatatum** being an invaluable grass, and it is now being eagerly sought for, since it has passed the stage of experiment. It resists both heat and cold (withstands drought, and frosts will not kill it), yields enormous quantities of fodder, is much liked by stock, and is shown by analysis to be of excellent quality. A good many people have found a difficulty in getting the seed to germinate. In our opinion this has been due to their sowing at the wrong time of the year, and in some cases where very unfavourable seasons, droughts, etc., have occurred, after sowing. Never sow in the fall of the year, but choose the early spring and summer, just before the ordinary season's rains may be expected. The quantity of seed to sow per acre varies with the requirements; 5 lbs. to 8 lbs. per acre on well prepared ground will soon result in a good paddock. If $1\frac{1}{2}$ lbs. to 2 lbs. per acre are sown, after grazing it should be held up about September, and allowed to grow on and shed all its seed naturally. It will soon spring up, and young grass if anything like a favourable season takes place, will be fit to graze in May. We consider that allowing the grass to shed its seed is the very best and surest method of thoroughly establishing a pasture. When the plants are far apart, the grass grows into big tussocks, but as soon as the spaces are filled up, it forms quite as good a turf as any of the other grasses.

"There is nothing hard or wiry about this grass, it is soft and succulent and there is no part of it from the crown to the seed heads that the stock will not eat."

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G. I. C. P. O.—No. 730 R. & A.—10·6·1901.—2,234.—C. M. W

THE

AGRICULTURAL LEDGER.

1901—No. 2.

AGENTS.

In England.

E. A. Arnold, Esq., 37, Bedford Street, Strand, London, W. C.

Messrs. Constable & Co., 2, Whitehall Gardens, London, S. W.

Messrs. Sampson Low, Marston & Co., St. Dunstan's House, Fetter Lane, London, E. C.

Messrs. P. S. King & Son, 2 & 4 Great Smith Street, Westminster, S. W.

Messrs. Luzac & Co., 46, Great Russel Street, London, W. C.

Messrs. Kegan Paul Trench, Trübner & Co., Charing Cross Road, London, W. C.

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In India.

Messrs. Thacker, Spink & Co., Calcutta and Simla.

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Superintendent, American Baptist Mission Press, Rangoon.

E. Seymour Hale, Esq., Fort, Bombay.

Rai Sahib M. Golab Singh & Sons, Mufid-I-Am Press, Lahore.

Messrs. A. J. Combridge & Co., Bombay.

(Agricultural Series, No. 34.)
(Food Substances.)

THE AGRICULTURAL LEDGER.

1901—No. 2.

(Reprint from original Report.)

TRITICUM VULGARE.

(WHEAT.)

[*Dictionary of Economic Products, Vol. VI., Pt. IV., T. 634-834.*]

Consult Agricultural Ledger, 1895, No. 20; 1897, No. 16.

AUSTRALIAN METHODS of TESTING and IMPROVING WHEAT: their APPLICABILITY to INDIA, with SPECIAL REFERENCE to the PREVENTION of RUST.

A Report by W. H. Moreland, Esq., I.C.S., *Director, Department of Land Records and Agriculture, North-Western Provinces and Oudh.*

CHAPTER I.—Introductory.

SELECTION OF WHEATS.

The work that has been accomplished by the Agricultural Departments of the principal Australian Colonies towards the establishment of wheat cultivation on an extensive scale falls naturally into two divisions. The first thing to be done was to test existing varieties of wheat and ascertain their defects when cultivated in the different agricultural regions of the Colonies; the second step was the attempt to produce new varieties or races, the habit of which should be more suited to local conditions, while the produce should be such as to command a high price in the European markets. The advantages of the system of testing adopted and of the methods of producing new varieties have at different times been pressed on the attention of the Government of India, and during my stay in the Colonies I have been enabled, through the courtesy of the officers of

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SELECTION OF WHEATS. Aim of Selection.

the Agricultural Departments, to make a careful study of both systems: the results of my enquiries are embodied in this report.

2. But before entering on a description of the methods adopted it is desirable to state the direction in which progress is looked for. There are two great natural hindrances to the extension of wheat-growing in those parts of the Colonies which are at first sight adapted for the purpose: in some of the moister regions summer rust (**Puccinia graminis**) is extremely prevalent, and indeed has in some localities practically put an end to wheat cultivation; in the arid regions, on the other hand, rust is not a dangerous enemy, but any serious deficiency in the small rainfall of these parts involves the entire loss of the crop. Thus, so far as agriculture is concerned the objects sought are to produce wheats (*a*) that will resist or escape the summer rust, and (*b*) that will come to maturity with a minimum supply of moisture in the soil. The quality of prolificness is subordinated to these main objects as it is considered better to have wheats that are fairly certain to yield a moderate return, than to rely on races that will give a great harvest in favourable seasons, but little or nothing when conditions are adverse. Along with these qualities the nature of the grain receives special consideration, the object being to produce grain of the kind most appreciated by millers using roller-mills, and consequently fetching the highest price in European markets. This again involves the conditions that the grain shall be fairly easy to mill and shall give a high percentage of flour, which must be "strong," rich in gluten, and of the colour and texture for which bakers are prepared to give the highest price. Another important quality is the possession of stiff straw, as any weakness in this respect interferes with the use of mechanical harvesters and the condition of the labour market puts hand reaping entirely out of the question.

3. It will be apparent from the above description that the qualities most desired in the Colonies are not in all cases important in India: it is not possible therefore to take Australian results ready-made and conclude that the varieties finally approved in the Colonies may at once be recommended for use by Indian cultivators. And even if the qualities required in the two countries were in all respects identical, there is another objection to the transfer of approved races from one to the other; the fact is that races of wheat are apt to change their character when transferred from one locality to another,

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SELECTION OF WHEATS.

even when the obvious conditions are not very dissimilar. Our knowledge of the life of any plant is confined to such a small portion of the whole that it is impossible to tell beforehand what will be the result of a transfer; all that can be done is to determine by experiment whether the sum total of the conditions present in the new country is favourable to the plant: and the result of such an experiment can be conveniently stated by saying that a variety is, or is not, adapted to a particular locality. I shall have occasion to use this expression later on, and I wish it to be understood merely as indicating that the resultant of the conditions in that locality is on the whole favourable to the variety. At any rate two facts cannot be disputed, (*a*) that in order to decide whether a given race of wheat is suited to a particular agricultural region it is necessary to test it in that region; and (*b*) that any marked change of conditions usually results in such a change in the character of the race as to materially alter the balance of important qualities. We cannot therefore take the facts ascertained in Australia and apply them to India: if an attempt is to be made to improve the nature of our wheats, it will be necessary to do the work ourselves: but we can adopt the methods that have succeeded elsewhere with a reasonable expectation of favourable results. Before improvement is taken in hand it is desirable to have definite knowledge of the advantages and defects of the wheats already grown, and a clear understanding of the qualities at which we should aim. The following chapter will therefore deal with the methods of testing.

CHAPTER II.—METHODS OF TESTING.

SELECTION IN AUSTRALIA.

4. In New South Wales, which leads the Colonies in this matter, the testing of varieties is carried on first in the field, and secondly in the laboratory. Nothing much need be said as to field trials: the system is well known in India, and a note explaining how it can best be carried out in existing conditions has been recently published in the Agricultural Ledger of the North-Western Provinces and Oudh (*vide* Bulletin No. 8 of 1900). The varieties selected for trial are sown in plots of uniform capacity; the plants are watched carefully during the critical periods of growth and the behaviour of each variety noted with special reference to any particular features (such as the amount of moisture available, the tendency to rust, liability to shed the grain before harvesting) that may be of importance

Field-tests.

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TESTING WHEATS.

in the circumstances. At the same time information is collected from practical cultivators who are accustomed to grow the variety on their holdings. When such trials and enquiries have been conducted, and the outturn of grain determined, over a series of years long enough to afford a fair sample of the climate that may reasonably be expected, it becomes possible to pronounce an opinion as to the relative suitability of the different varieties for the locality, or rather the agricultural region, where the experiments have been carried out.

5. It is, however, necessary to remember that the conclusions drawn from such trials are not of wide-spread or general application. Each agricultural region must stand by itself, and the varieties suitable to it must be determined by direct experiment within its borders. In New South Wales, experimental farms exist, I believe, in every region that can be recognised as having a distinct climate, and the best varieties can thus be determined for each region.

Laboratory-tests.

6. The system of laboratory testing employed in New South Wales (*a*) requires more detailed description, as, so far as I know, nothing like it has been attempted in India. It may be premised that (with the exception of certain wheats specially suited for making macaroni, and consequently commanding a high price in the markets of Southern Europe) practically the whole of the wheat produce of the Colony is destined to be converted into flour in roller-mills of the modern type. Hence the tests applied are directed towards ascertaining the presence or absence of the qualities specially appreciated by the miller and the baker. A report on a given sample of wheat is drawn up in the following form :—

(1) Variety of grain.
(2) Appearance of grain.
(3) Weight per bushel (lbs. per bushel).
(4) Ease of milling.
(5) Percentage of mill products { Flour. Pollard. Bran.
(6) Nature of flour . . { Colour of flour. Strength of flour (quarts of water per sack of 200 lbs.). Percentage of dry gluten.

(*a*) I am indebted to Mr. W. M. Guthrie, F.C.S., Chemist to the Agricultural Department of New South Wales, for the opportunity of studying these tests in the laboratory in his charge.

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The first head gives the name of the variety as submitted (*b*) and the second describes the appearance of the sample, an important matter as millers are accustomed to judge grain to some extent by the eye. The third head—weight per bushel—is important where the cumbrous system of selling grain by the bushel (or quarter) of so many pounds prevails: were the trade conducted (as in the interior of India) purely by weight, this heading would be of no importance.

The ease or difficulty of milling is important from the miller's point of view: with some varieties the flour can be readily separated from the other products, in others it adheres to the bran and repeated operations are necessary. Ease of milling cannot be determined objectively: the report on this point is the opinion of the experimenter based on his observations of the process, and consequently it contains a subjective element.

To ascertain the percentage of mill products, the sample of grain is put through a miniature roller-mill, under conditions as nearly as possible similar to those which prevail in practice; and the percentage of the various products determined by actual weighment. These figures are of course most important to the miller, who will (*cæteris paribus*) pay a higher price for wheat which gives a higher percentage of flour.

The colour of the flour is judged by pressing part of the sample so as to present a smooth surface and then moistening it; the colour and quality of the surface are then compared with standards and named accordingly. I understand from the experts who carry out these tests that colour has not been found to be uniformly correlated with any really valuable quality in the flour; the colour is tested because bakers prefer a flour of a particular colour.

Similarly the "strength" of flour is important mainly from the baker's point of view. A flour is said to be "strong" in proportion to the amount of water it will absorb: to the baker this simply means that a given weight of a strong flour will bake into a larger quantity of bread (by weight) than the same quantity of a weaker flour, or in other words that he can make more or larger loaves from the same weight of a strong flour than from a weak. Recent investigations

(*b*) The nomenclature of the varieties commonly grown in the Colonies has been authoritatively determined by a conference: new varieties produced by Mr. Farrer are named by him as soon as they are fixed.

TESTING WHEATS.

show that the strength of flour depends on the constitution of the gluten. Gluten contains two proteids (known as glutenin and gliadin) which occur in very different proportions in different flours; and the greater the proportion of glutenin to gliadin, the stronger is the flour. The chemical composition of these two proteids is very similar, and it has not to my knowledge been shown that their nutritive values are appreciably different; but the strong flours offer some advantages to the consumer as well as to the baker. "The loaf produced by a strong flour is a better one, the process of fermentation is more uniform, and a better-risen and better-aërated loaf is the result, yielding consequently a more digestible and wholesome bread" (Mr. W. M. Guthrie in the Agricultural Gazette of New South Wales, October 1900, page 865). It will be seen that the advantages of strong flour *to the consumers* arise when the European method of baking is followed: they would be much less important, if they exist at all when the flour is baked into flat unleavened cakes as is usually done in India.(*c*)

The proportion of dry gluten in the flour is a different matter, as the nutrition-value of flour may be said to vary directly with the percentage of gluten; this test therefore, unlike those which have just been mentioned, must always be applied when it is desired to compare the real value of different flours. The method by which this proportion is determined is given in the footnote (*d*).

Cost of Laboratory-apparatus.

7. The cost of complete apparatus for carrying out these tests would probably be from £50 to £60; the roller mill alone would cost about

(*c*) The method in use for determining the strength of flour is thus described by Mr. Guthrie in the paper quoted above—

"One and-a-half ounce of flour are placed in a capacious flat dish, and water is added from a graduated burette, the flour being kneaded into a dough. When all the flour is made into dough, the addition of water is continued gradually, in small quantities at a time, the dough being well worked between each addition. This is continued until the dough when tightly squeezed in the palm of the hand can no longer be cleanly removed with the other hand; in fact until it has become just unworkable. By taking a properly graduated burette, the amount of water in quarts may be at once read off."

"(*d*) Ten grammes of flour are made into fairly stiff dough with a little water. The lump of dough is allowed to stand covered with an ordinary glass tumbler for one hour. It is then kneaded with the fingers under water in a thick-walled glass apothecary's mortar, the water being poured off and fresh added as long as it becomes milky. The advantage of using a glass mortar is that you can see what is going on: you can thus detect the slightest milkiness in the water, and you can detect any stray pieces of gluten that may possibly become detached during the operation.

"Having washed the gluten thoroughly, it is placed in a small porcelain or glass basin (the weight of which is known), and dried at 100°C for three hours in an air oven. After this time it is weighed, and the original weight of the basin being subtracted the remainder is the weight of dry gluten in ten grammes of the flour."

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TESTING WHEATS.

£40. The tests can be applied only by a person who has had special training: the Agricultural Chemist, who is in charge of the work, estimates that a man of good abilities with fair general scientific knowledge would require four months' training in the laboratory before he would be qualified to work independently.

8. By this dual system of testing, first in the field and then in the laboratory, complete information is obtained as to the value of each strain or race of wheat. The first set of tests shows the character of the plant, the yield of grain, the power of withstanding drought, and of escaping or resisting rust, and the other qualities the sum of which shows whether or not the race is adapted to the particular agricultural region. The laboratory tests show the value of the product when placed on the market, and they secure that undue weight shall not be attached to mere productiveness irrespective of the quality of the produce. The system, as a whole, is admirably adapted for use in a country the produce of which is destined to be made into bread by European methods, and its value is highly appreciated in the Colonies: but for certain reasons it is not entirely suitable to India. The explanation of these reasons requires a consideration of the objects of wheat growing in India.

Australian methods not entirely suitable to India.

9. So far as wheat is grown for European consumption the object of the Indian cultivator should be to get the maximum yield of wheat giving the best quality of flour (estimated as is done by up-to-date millers): where artificial irrigation is available the crop is practically independent of drought, so that there is not the same reason as in the Colonies for preferring a hardy to a prolific variety, and the whole attention of the cultivator can be given to producing the greatest weight of grain of good quality. In dry tracts, on the other hand, the quality of drought-resistance becomes of the utmost importance. The danger of rust also exists: in some parts of India, such as the Gangetic duab, the varieties now grown as a rule suffer little actual loss from rust, having apparently become adapted to the locality in this respect: but elsewhere, particularly in the Central Provinces and the Bundelkhand districts of the North-West Provinces, rust-resistance appears to be an essential quality of any race; and there is every reason to think that new races introduced into country like the duab (where existing races appear to be more or less immune) will be particularly liable to be attacked by the fungus.

Qualities important in Indian Wheat.

10. If then most of the wheat grown in India were intended for

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the European market, the New South Wales system of tests might be applied in its entirety and the expense of training operators and setting up the necessary machinery would be justified by the importance of the work that could thus be accomplished. But, as a matter of fact, the wheat produce of India is destined for consumption in the country: in exceptional years when a good harvest coincides with a period of high prices in Europe, the export of wheat reaches a total which, absolutely, is enormous; but even then it is only a fraction of the total production, and, taking the figures for a long series of years, the fact becomes apparent that the Indian market is much more important to the cultivator than any other. It becomes therefore necessary to enquire what are the characters required in that market.

11. Under present conditions of social life (and they are not likely to change very rapidly) the bulk of the wheat consumed is ground into *ata* (that is, meal rather than flour) in the ordinary stone hand-mill, and the meal is baked into unleavened cakes. Most of the laboratory tests employed in New South Wales thus become irrelevant, the only one of indisputable importance being the proportion of gluten. The other qualities important to the consumer are ease of grinding in hand-mill, loss in grinding, and certain conventional matters affecting colour and texture which probably differ in different localities.

Suggested Tests for Indian Wheat.

12. It seems to me then that the testing of wheats for growth in India can be effectively carried out as follows: there must of course be field trials, on the lines already described, for each agricultural region; and there should be some simple tests of the produce. The simplest of all is a valuation by grain dealers, if trustworthy men can be found, and by educated consumers: and this can be supplemented by tests of the gluten-content (which could doubtless be carried out in the Dehra Dun Laboratory), and by a practical milling test in a standard hand-mill, a very simple affair which could be done at any experiment station. Such tests would be sufficient to determine the suitability of produce for the Indian market; if it is considered that the prospects of the export trade from any regions are so great as to make it necessary to pay special attention to the needs of millers, then it would be desirable to set up a testing mill of the kind employed in New South Wales, and to have an operator trained to use it; in that case it would probably be most convenient to have the work done at

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the Dehra Dun Laboratory. Judging, however, from those parts of the country with which I have a personal acquaintance, the export trade in wheat is not of such relative importance as to make the introduction of these tests essential.

CHAPTER III.—Scientific breeding of improved races of wheat.

Means of Improving the race.

13. When it has been ascertained by some of the methods discussed in the preceding chapter that the race or races of wheat grown in any agricultural region suffer from certain defects: being either comparatively unproductive, or liable to injury from disease or irregularities of season, or yielding produce of a kind not liked in the market: the next step is to introduce an improved race. The first attempt in this direction is usually to import into the region some variety that has been successful elsewhere: this may or may not succeed, but for reasons that have been explained in the first chapter success is not antecedently probable, and in any case it is purely a matter of chance. The alternative is to breed new varieties more suited to local conditions; and it is in this direction that so much progress has been made in the Colonies, particularly New South Wales. The subject was there taken up by Mr. William Farrer, who worked at first independently and for the last two years as a Government officer. I have to express my warmest thanks to Mr. Farrer for the very great kindness and generosity with which he has placed at my disposal the whole of the method and results of his work; he has taken the greatest pains to explain every point of the elaborate system which he has devised, and has given me ample opportunities for practical work on his own breeding-grounds.

Selection without Breeding.

14. The principles which lie at the foundation of Mr. Farrer's work are well known to science; they may be called improvement by selection and production of variations by means of crossing. The first principle is that which was followed by the earlier breeders of "pedigree" wheat, and the method ordinarily adopted was to pick out the individual plants or even individual grains which possessed in the highest degree the special characters which it was desired to increase; to sow the seed of these and from their produce pick out the most desirable plants; and to proceed in this way until eventually a race was established having the desired characters in a markedly greater degree than the parent variety. The objections to this

Selection slow and selected race liable to revert.

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OBTAINING NEW WHEATS.

procedure in the case of wheat are two: the natural variations are comparatively few and small, and the improved race tends to revert to the condition of the parent variety when the process of selection is no longer continued.

15. The first of these objections appears to follow from the structure of the ear. It is common knowledge, as a result of the work of Darwin and others on the subject, that cross-fertilisation tends to produce variability in the offspring: now the flowers of wheat are fertilised by their own pollen while still closed and at a time when extraneous pollen cannot enter the unfertilised flower, so that cross-fertilisation very rarely if ever takes place under natural conditions. The flowers being self-fertilised, the offspring reproduce the character of the parent in general with great accuracy, and marked variations such as form the most satisfactory starting point for selection are rarer than would be the case if cross-fertilisation were usual. The second objection greatly limits the value of improvements accumulated by selection alone; such improved breeds can be trusted to maintain their character only if the seed-stock is periodically renewed: otherwise they gradually deteriorate. Farmers can grow them if they are in a position to obtain regular supplies of seed from growers who devote their time specially to selection; but where other conditions prevail (as is certainly the case in India) the introduction of improved breeds produced by selection alone can be at most a temporary benefit.

Breeding of new Wheats.

16. The system followed by Mr. Farrer starts with the production of variations by artificial crossing. Leaving out all details of technique, it may be described as follows: having decided to mate two varieties, the unfertilised flowers of one are carefully castrated and are then pollinated from the other. The seeds thus produced are carefully saved, and sown by themselves: the produce of this (the first) generation is again saved plant by plant, and again sown separately. It is in this, the second, generation that the greatest variability appears: and a glance at a row of plants of this generation is sufficient to show the very marked degree of variability which characterises them. From this generation any plants showing the characteristics specially desired are picked out for seed and the regular process of selection follows with the offspring until after some years a race has been developed which possesses these characteristics in a high degree. The tests already described are of course applied

Method of obtaining and fixing new breeds.

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to the produce, and if the race is found suitable it can be recommended for general use; or it can be used as the parent of other varieties to be produced in the same way. The time required for "fixing" a new race varies greatly: some come true after three or four years, while others continue to show marked variability for a much longer series of generations, but it is an important fact that these races, unlike those produced by selection without previous crossing, appear to be permanent, and so suited for use by persons who save their own seed.

OBTAINING NEW WHEATS.

Influence of locality on new breeds.

17. In all this work the influence of locality has constantly to be borne in mind. Mr. Farrer prefers, when such a course is possible, to grow some at least of the produce of "the first generation" in that particular place or places for which the breed is designed; and to have the process of selection, commencing with the second (or variable) generation, carried out in that locality. When owing to the absence of the necessary facilities this cannot be arranged, and the selection is made in some other region, the process cannot be relied on to give such sure results.

Some rules for breeding.

18. It is not possible to reduce the whole breeder's art to rules: knowledge of the behaviour of individual varieties is necessary to enable a proper choice of parents to be made, and this knowledge can be obtained only by practical experience ranging over a number of years. Mr. Farrer has laid down the following principles as embodying some results of his experience:—

(1) Fairly good results can often be obtained by mating varieties almost at random, provided they be of different types.

(2) Better and more certain results can be obtained if the parent varieties have been chosen for possessing, even though it be only in a moderate degree, as natural attributes, the qualities which are wanted.

(3) While the best results of all will follow from the crossing of varieties which, while they possess naturally in the highest degree which has been obtained, the quality or qualities which are desired in a still higher degree, have had these qualities temporarily increased in them by a preparatory course of selection.

19. In carrying out the process of selection the cardinal rule is to take the plant as a unit; and to sow the produce of each selected

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plant separately from all other plants, and in such a manner that its behaviour can be observed. And finally one more important principle may be stated: before commencing work the objects to be attained should be clearly defined.

20. As regards the relative influence of the parents, Mr. Farrer is not prepared to lay down any rule as to which parent has the greater effect on the different parts of the plant, and probably the safest course, when it can conveniently be adopted, is to make reciprocal crosses and compare the offspring of the two crosses, selecting from them those which appear to be most suitable for the purpose in view.

21. In the above account I have, as far as possible, omitted all technical matters. The methods of castration and pollination are difficult to describe on paper within reasonable compass, while they can be readily learned by seeing the processes in operation: they require merely an ordinary knowledge of the structure of the flower, and a certain amount of care and manual dexterity, easily acquired by practice. A very complete system has been devised for marking the plants possessing special characteristics, and for harvesting and storing the seed of the individual plants selected: the need of such a system will be obvious when it is considered that in the area of less than two acres occupied by Mr. Farrer there are about 1,000 different races, and about 80,000 individual plants. I have drawn up a code of instructions embodying Mr. Farrer's system with such modifications as appear to be needed to adapt them to Indian conditions; this code will be available for use if the system of scientific breeding is adopted in India, but it is unavoidably very long, and of purely technical interest: I do not therefore embody it in this report.

Need of a system in extensive experiments.

22. There is no doubt in my mind that Mr. Farrer's work in New South Wales has already secured a large measure of success, and gives promise of much greater results in future. This conclusion cannot perhaps be definitely established by arguments addressed to those who have not seen the improved races growing under the conditions for which they were bred: it has been formed as the result of numerous enquiries and of a detailed study, extending over a month, of the wheats growing in Mr. Farrer's breeding-ground. Two sets of facts may, however, be mentioned as illustrations of those on which the conclusion rests. The first is the comparison of new wheats

Success in Australia.

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with old where all were growing together. As it happened, the season during my visit was very dry, the moisture in the soil was quite insufficient and most of the well-known prolific varieties of wheat were suffering very much: alongside of them were to be seen newly bred races growing under exactly similar conditions but in almost perfect vigour and health. A detailed inspection of the plants was to my mind quite conclusive of the advantages possessed by the new races as drought-resisters. The second set of facts was observed during a visit to the hot and dry regions in the north-west of the Colony. This country is used mainly for stock-raising, but occupiers usually like to have a few acres under crops, which, however, with a rainfall of ten inches or under, the record of the last few years, are a very doubtful speculation. At the time of my visit to this part of the country the wheat should have been coming into ear, but had generally been ruined by the drought, so that what was left in the fields was being fed off by stock. Thus in that region the ordinary wheats were practically an entire failure: but some of Mr. Farrer's wheats grown under the same conditions succeeded as is shown by the following extract from a letter of the Manager of the Coolabah Experimental Farm: "We have harvested Mr. Farrer's wheats and they were satisfactory, many having very fair grain." I admit that this result surprised me, for the soil on this farm is naturally in a wretched condition, and it appeared to me hardly possible that it could supply enough moisture for any cereal to mature in such a season.

23. The success attained may be attributed to a combination of three elements; the system itself is sound, a sufficient number of farmers are ready to try new varieties, and the right man has been found to do the work. Of the soundness of the system there can be no doubt on scientific grounds; but it might have happened that the results obtained were nullified by the conservatism of the farmers. That quality, however, though still in evidence, has been pushed into the background by the severe calamities that have visited the Colonies. Thus the continued prevalence of rust practically annihilated wheat cultivation in the coastal districts of New South Wales; and in the dry country drought bid fair to prevent the establishment of the industry. It has become obvious that many of the wheats ordinarily grown are hopeless, and that the only chance of continuing to cultivate the crop is the adoption of varieties better suited to the conditions that prevail.

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Conditions in India which may determine the possibility of success.

Conservatism of Indian farmer and prejudice.

24. In considering then whether the system of scientific breeding should be introduced in India the question arises whether there is any chance of the cultivators accepting new races of wheat. The Indian cultivator is popularly credited with a degree of conservatism unusual even among farmers in this respect, but he is not without excuses. In the first place, a man with a small holding cannot possibly take the risk of an experiment, the failure of which will mean, not a decrease of the balance at the bank, but an actual deficit in the food-supply of his family; and in the second place, it must be admitted that some kinds of seed largely distributed by the Agricultural Departments in past years have proved to be unsuitable to the needs of the country, and have therefore given some grounds for prejudice. It is necessary to be quite sure that we have improved varieties to offer before we can be sure whether or not the cultivators will accept them: and I do not think the Department has sufficient experience in the introduction of undoubted improvements to justify the conclusion that cultivators will not accept varieties which are obviously better than those in common use. In my opinion then the conservatism of the cultivator is not a sufficient reason to justify the rejection of the system of scientific breeding: but it is a factor of the problem that must be borne in mind, and its existence makes it desirable that the initial work should be done on a moderate scale and with no avoidable expense.

Need of an Expert.

25. I have ventured to name the personality of Mr. Farrer as the third cause contributing to the success of his work; it is questionable whether we can count on securing so much skill and devotion for work in India. At the same time work would be started with some obvious advantages: Mr. Farrer had to work out practically the whole system for himself, while we have the full benefit of his experience; we have also the power of getting routine-work efficiently performed at a trifling cost.

26. On the whole then, while it would undoubtedly be most satisfactory to employ an expert enthusiast and give him a perfectly free hand, it is very doubtful if the expert enthusiast would be found, and it would not be proper to go to so much expense if the work can be carried on by an adaptation of existing agencies. As I have just said, the routine-work presents no difficulty; success must depend mainly on the accumulation of an organised and available body of knowledge regarding the behaviour *as parents* of a large number

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of varieties. In New South Wales such an organised collection of knowledge is possessed by Mr. Farrer, but it seems hopeless under existing Indian conditions to rely on continued personal work, and it becomes necessary to substitute a detailed record of such knowledge to be made as acquired, thus extending as far as possible the dominion of routine and requiring as little as possible in the way of judgment. At the same time I hope that among the men employed we may find some one with the habits and interests which are the best equipment of the breeder, but my object is to rely on these as little as possible. The scheme which seems to me on the whole most suitable is outlined below, it being premised that the estimates of cost are necessarily somewhat provisional.

Scheme for a Central Station for breeding new Wheats.

27. On grounds of economy and general advantage, I recommend that—at the start at any rate—there should be one central breeding station for the whole of India. The principal advantages of centralization are that the accumulation of information will be more rapid and that the whole of it will be readily available. The work at this station would be limited to breeding and to the processes of selection which are a desirable preliminary (*cf.* paragraph 16). The rest of the work would be carried out by the provincial departments: that is to say, the examination and study of existing varieties, and the ascertainment of their defects must be done locally for each agricultural region where wheat is an important crop. The results of these enquiries would be intimated to the officer in charge of the central breeding station who would endeavour to produce new races of wheat generally suited to the locality in question and not so liable to the defects that had been detected. Seed of the new races would then be sent to the provincial department for trial and selection *in the agricultural region concerned.* These proposals involve that there shall be an experiment station of some sort maintained by the provincial department in the agricultural region where improvement is contemplated; but a large farm and an expensive establishment are not necessary. The amount of land required for a selection station will hardly ever be more than two acres: and the work of marking the plants for selection could be taught to any official of moderate intelligence in the course of a month's training at the central breeding station.

Connection with provincial departments.

Staff.

28. The work of breeding can be carried out by any one with a good general education, a practical knowledge of botany and a taste

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for the work. The right men can, I think, be found among the best of the diplomates of the Cawnpore Agricultural School; as most of these students are entitled to revenue posts on Rs. 30 soon after leaving school, the starting pay cannot be less than that sum, and slightly higher pay will be necessary to attract the best men. It is essential to allow adequate time for the study of the wheats, and to make provision for vacancies arising from sudden illness or similar causes. I would therefore have a breeder and one assistant at the station where breeding is carried on.

Expenditure.

29. It is no less essential to maintain continuity of service, and in order to secure this the posts should be made permanent and pensionable, and the pay should rise by increments over a long series of years. Having regard to these considerations I would fix the pay as follows:—

Breeder Rs. 40 rising by increments of Rs. 3 to Rs. 70

Assistant Breeder Rs. 30 rising by increments of Rs. 2 to Rs. 50

Annual contingent charges would be about Rs. 200 and there would be some initial expenditure on a store-house and work-room and its fittings.(*e*) It should also be recognised that, if the ideal breeder is found, proposals might be submitted for increasing his pay beyond Rs. 70 in order to be sure of retaining his services.

Location and control.

30. The central station should, in my opinion, be located at the Cawnpore experimental farm: land (about two acres at most would be needed) could be spared there, and the work of cultivation could be carried out cheaply and efficiently as part of the ordinary farm work. For the first year at any rate the work would have to be done under my close personal supervision which can be given better at Cawnpore than anywhere else: when things are in working order the supervision of the establishment might be made part of the duties of the Deputy Director.

31. The only difficulty in this arrangement would be that for the first year I should have to give up all inspection work on the Land Records side of the Department: my office work would not be interfered with, but it would be impossible for me to leave Cawnpore for more than a few days between October and the following May. If this matter can be arranged with the Local Government, preferably by the deputation of an officer to the department to perform my

(*e*) The store-house and work-room would be 20 ft. × 10 ft.: walls *kacha-pakka*, roof Allahabad tiling, and concrete floor. From these details the cost may be roughly estimated. Fittings would cost about Rs. 250.

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inspection duties, I am of opinion that I could give sufficient supervision to ensure a proper start of operations. After the first year occasional visits to the station would be sufficient.

Initial Work and Expansion.

32. As a commencement, the breeders would be employed in the study and selection of various wheats, and in making those crosses which appear likely to give rise to new wheats with drought-resisting and rust-escaping characters, specially suited for the Central Provinces and the Bundelkhand districts of the North-Western Provinces. The work would gradually expand as requests for improved wheats arrived from other provinces or localities, and meanwhile both the supervising officer and the breeders would, by their detailed study of a large number of varieties, be gradually acquiring the experience which is needed as a foundation for successful work. Probably if the breeding station is a success, that is to say, if good wheats are produced and the cultivators take to them, it will be necessary to put the whole work in charge of a qualified European: but in that case the expenditure would be amply justified by results, and the question does not arise at present.

Provision of Cost.

33. I believe that by the scheme which I have outlined above, a scientific breeding station can be established at the lowest possible cost, and in such a way that expansion can be provided as required; the annual cost which would at first be about Rs. 1,000 and would rise gradually as increments accrue, as well as the initial cost of a storehouse, could presumably be met from the budget of the Imperial Agricultural Department; the cost of cultivation would hardly be susceptible of separate calculation and may fairly be met from the allotment for the Cawnpore Farm in the provincial budget of the North-Western Provinces and Oudh: in return for this small provincial expenditure the Agricultural School (or College when one is established) at Cawnpore will be provided with admirable facilities for the practical study of agricultural botany. The work of selection from the seed supplied by the central station must necessarily be done by the provincial department interested.

PREVENTION OF RUST.

CHAPTER IV.—Observations on the prevention of rust.

Extreme Localization of quality of rust-resistance.

34. Turning now to the special subject of rust-prevention, the orders deputing me to the Colonies indicated—

(1) that I should endeavour to obtain a supply of rust-resistant varieties of wheat for use in India:

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(2) that I should study the methods adopted for the prevention of rust.

As regards the first point, I have decided that it would be unwise to bring over any large stock of rust-resistant varieties. My chief reason for this decision is that the climate and agricultural conditions prevailing in India are so different from those of the Colonies that it is not possible to infer that a resistant variety in New South Wales will show the same character in India. Mr. Farrer and all other competent judges lay particular stress on the extreme localization of the quality of rust-resistance, and consider that that character can be secured only by selection within a particular locality. At the same time Mr. Farrer has very kindly promised to send me the offspring of crosses that appear likely to succeed in India, in order that they may be added to any breeding establishment that may be set up; and he has also made some crosses specially for Indian use.

Varieties proved rust-resisting in Australia may not be so in India.

Want of complete knowledge of Rust-fungus in India.

35. The second object of my deputation was the study of the methods adopted for the prevention of rust; the results of this study are recorded above in the description of the process by which new varieties with particular qualities are produced. In applying these methods to the production of rust-resistant varieties, it is necessary to bear in mind that the natural history of rust, whether in India or Australia, is not completely known, and that the work must consequently be to some extent empirical. We do not know for certain what form of rust is to be guarded against; and we certainly do not know the complete life history of the organism or organisms which are most destructive in India. Until therefore the scientific study of the organisms has made considerable progress, the process of producing rust-resistant varieties must be based on systematic breeding from those varieties or individual plants which, as a matter of fact, escape rust in a season when other varieties, or the other individuals of the same variety, are attacked. The proposals submitted in the preceding chapter provide fully for this work.

Typical Characteristics of Australian Rust-resisting Wheats.

36. In choosing the parent varieties for this purpose, it will be desirable to pay special attention to the results of Australian experience as regards the features of plants which render them more or less liable to rust. Mr. Farrer enumerates the typical characteristics of a rust-resistant plant as follows (*f*) :—

(1) The straw and foliage should have a covering of close

(*f*) The enumeration in the text differs slightly from that published by Mr. Farrer some years ago and reproduced in the Agricultural Ledger; the differences are the result of increased experience.

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texture, and be well glazed, and well covered with bloom of a dark glaucous colour.

(2) The growth should be spare rather than gross.

(3) The flag and foliage, in addition to being well glazed and of close texture outside, should be erect, narrow and stiff, not heavy, broad and flabby.

(4) The time of maturity should be early: this character enabling a variety to develop before the onset of the stem- or summer-rust.

(5) The characters enumerated above are all subject to the condition of locality, in other words there is a power of rust-resistance, as yet undefined, which for the same race of wheat varies with the locality.

It cannot, in the absence of experimental data, be said to be proved that these conclusions, derived mainly from the study of Australian conditions, apply in their entirety to India; but what is known of the general habits of the rust organisms makes it highly probable that the same features will be found of advantage wherever rust prevails. While therefore the breeders should not aim merely at the production of the first four of the characters just enumerated, careful notice must be taken whether these characters exist in the plants that escape infection, and probably the best results will be secured by starting work on those varieties which, on the whole, conform most closely to Mr. Farrer's description.

Rust and Drought may work together. A Wheat might be bred to resist both.

37. I believe it is the case that those parts of India where rust is most severe are also most liable to suffer from drought; certainly this is so as far as the North-Western Provinces are concerned. Rust is rarely more than a slight calamity in any part of these provinces except in the Bundelkhand districts, which are notoriously most liable to suffer from any failure of the rains. Now for practical purposes it is obvious that the most desirable wheat for general use in such localities is one that will resist rust and at the same time be able to exist on a small quantity of moisture. Whether such a wheat can be produced by scientific breeding is a question for experiment; but it may be noticed here that none of the characters enumerated by Mr. Farrer require a great supply of moisture, while the moderate growth, and the narrow, hard flag are features that would usually be associated with the wheats of a dry region. There is therefore no reason to suppose that rust-resistant wheats will be specially liable to

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suffer from drought; and there is a possibility that they may be specially adapted to resist it. The possibility of producing such varieties is to my mind in itself sufficient justification for establishing a breeding station on the lines which I have recommended. (*g*)

CHAPTER V.—Summary and conclusion.

SUMMARY.

38. In conclusion I may summarize my recommendations as follows :—

(*a*) The adoption of the New South Wales system of testing the value of grain appears to be unnecessary so far as the Indian market is concerned. If it be considered desirable to adopt the system with a view to the export trade, it would be sufficient to have one testing establishment for the whole of India which might be located at the Dehra Dun Laboratory.

(*b*) The system of scientific breeding can be introduced at a very moderate expense and with fair hope of valuable results. The most suitable arrangement would be to have a central breeding establishment at Cawnpore, placed at the outset under my control, and in direct communication with the different provincial departments. It will be for provincial departments to decide in what respects their local wheats are deficient; the central station will on request breed wheats such as may be expected to be an improvement on those in use, and will supply these to the provincial department: the latter will arrange for the cultivation and selection of the new breeds, so that these processes may be carried out in the agricultural region for which the wheats are intended.

(*c*) The trifling expenditure incurred in this work of selection should be borne by the provincial departments, the Imperial Government providing the cost of the central breeding station.

(*d*) The first work of the central station should be an attempt to produce wheats that will, as far as possible, stand

(*g*) To avoid the possibility of misconception I may explain here that the character of drought-resistance cannot be expected to secure crops when the land is too dry for sowing: its value would appear in seasons when the varieties ordinarily in use get a start but wither owing to the scantiness or absence of the winter rains and the dryness of the soil.

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drought and resist or escape rust: the future developments will depend on the reports received from the various departments.

Acknowledgment of Services.

39. It only remains for me to place on record my gratitude for the ready assistance which I have received during the progress of my enquiries in the Colonies. In particular I have to acknowledge aid and information received from the following gentlemen:—

The Honourable Mr. J. Fegan, Minister of the Department of Mines and Agriculture, New South Wales:

The Railway Commissioners of New South Wales:

D. C. Maclachlan, Esq., Under-Secretary, Department of Mines and Agriculture, New South Wales:

P. McLean, Esq., Under-Secretary, Department of Agriculture, Queensland:

W. M. Guthrie, Esq., Agricultural Chemist, Department of Mines and Agriculture, New South Wales:

H. Pye, Esq., Principal of Dookie Agricultural College, Victoria:

J. T. Valder, Esq., Principal of the Hawkesbury Agricultural College, New South Wales:

The Managers of the Experimental Farms at Coolabah and Bathurst (New South Wales) and at Westbrook (Queensland):

and finally I must again express my warmest acknowledgments to Mr. Farrer for his great kindness and his cordial willingness to supply me with all the information at his disposal.

G. I. C. P. O.—No. 822 R. & A.—3-6-1901.—2234.—C. M. W.

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(Spices and Condiments)

THE

AGRICULTURAL LEDGER.

1901—No. 3.

PIPER NIGRUM.

(PEPPER.)

[*Dictionary of Economic Products, Vol. VI., Pt. I.,* **P. 811-20.**]

CULTIVATION OF PEPPER IN THE BOMBAY PRESIDENCY.

A further account of Manures used in Spice Gardens.

By J. MOLLISON, ESQ., M.R.A.C., *Deputy Director of Agriculture, Poona.*

GREEN MANURING OF PEPPER.

[The Survey Commissioner and Director, Land Records and Agriculture, Bombay, having furnished this office with a copy of Mr. Mollison's report No. 547, dated the 7th October 1900, (on the above-mentioned subject) the following extract from it is given as a supplement to *The Agricultural Ledger* No. 3 of 1900. The additional information will be found to include enumeration of those trees, the leaves of which are commonly used for leaf manure, as well as the chemical analysis of the different kinds of leaves, manures, and soils by Dr. Leather, Assistant Agricultural Chemist to the Government of India. The information thus furnished may be found of interest as a contribution to the large question of GREEN MANURING.] *Ed.*

Sources of Green Manure.

The more common trees in *beta* lands and in protected forest, which are specially useful to the cultivators, for manure purposes, are referred to in short detail below :—

Kaval or Kavla (*K.*)* (**Careya arborea**, *Roxb.*)—Leaves big, fleshy, soon rot as green manure, and considered specially good for leaf-mould. Trees abundant in *beta* lands.

* (K) indicates that the name is Kanarese, (M) that it is Malayalam.

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Honne (*K.*) (**Pterocarpus Marsupium**, *Roxb.*)—Leaves are rather small and are not considered particularly good for leaf-mould.

Jambe (*K.*) (**Xylia dolabriformis**, *Benth.*) Used more as a covering for the leaf-mould manure as light branch wood than for leaf-mould. They do not decay quickly.

Hirda (*M.*), *Alale* (*K.*) (**Terminalia Chebula**, *Retz.*)—The best leaves of all for green leaf-mould, and are supposed to kill insects and grubs. Leaves small and do not rot very quickly. They are eaten as fodder by cattle.

Kanagal (*K.*) (**Dillenia pentagyna**, *Roxb.*)—Leaves are good for leaf-mould. They are very large and fleshy and decay very quickly. Flowers, buds and fruit eaten. Berries eaten greedily by deer and other animals.

Honal (*K.*) (**Terminalia paniculata**, *Roth.*)—Considered nearly as good as *matti* for leaf-mould. Leaves not large and do not decay particularly quickly.

Matti (*K.*) (**Terminalia tomentosa**, *Bedd.*)—Leaves and branches considered excellent for leaf-mould, the former large and easily collected. Leaves used as cattle fodder.

Nerlu (*K.*) *or Jambul* (*M.*) (**Eugenia Jambolana**, *Linn.*)—Used to a considerable extent for a leaf-mould or for branch wood, used as a covering over leaf-manure.

Bite (*K.*) (**Dalbergia latifolia**, *Roxb.*)—Blackwood. Reserved as a valuable timber tree.

Nelli (*K.*) (**Phyllanthus Emblica**, *Linn.*)—Branches also used as protective covering for young cardamom seedlings. Fruit and leaves good fodder.

Surhonne (*K.*) (**Calophyllum tomentosum**, *Wight.*)—Sirpoon tree. Evergreen. Found in *Káns*, not in *beta* lands or protected forest.

Kari Muttala (*K.*) (**Ougeinia dalbergioides**, *Benth.*)—Leaves used for fodder.

The best timber trees are not the most useful for manure.

2. It will be noticed that the unreserved trees which are reported to give the most useful leaves and branches for garden requirements have no great value as timber trees.

Value of the green manure compensates for the slow destruction of the tree.

3. A Kanara gardener requires that the leaves for green manure shall be within his reach so he pollards and lops. Afterwards the foliage (it is cut every second year) is within easy reach and for a number of years a large amount of both foliage and light-branchwood

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is produced. In course of time the tree dies prematurely by exhaustion or ill-health induced by bad usage. The pollarding practised unquestionably shortens the life of trees. It will also diminish their full value when dead, because they have spent their substance in producing by unnatural treatment leaves and small branches instead of natural growth. But the result justifies the means, because small branches and leaves are specially required by the gardeners. And if young trees of suitable varieties are so protected that they replace old decayed trees, and if pollarding is prohibited until young trees attain certain dimensions as proposed by the Committee in the draft rules, then I think the interests of Government will be fully safeguarded, and the requirements of the gardens fully maintained. I saw numerous instances of well-managed *beta* lands. I saw also instances of ruthless destruction with the surface burnt to encourage grass, and no forest undergrowth to speak of, but side by side with these badly managed *beta* lands there was even greater destruction in protected forest for which the people at large, and not the garden owners alone, were responsible.

Dead leave will not do.

4. It is suggested in the papers that the full requirements of the garden occupants could be met if they gathered dead leaves and grass in enclosed forest to supplement the supplies of green leaves and twigs got from assigned *beta*. It is also urged that the dead leaves and grass would not be less valuable for manure than green leaves and twigs. I cannot support these views. Leaves, as they become perfected, dry up and become fibrous and a good deal of the plant food, both mineral and organic which they contained when green and growing, passes from them and is utilized in increasing the size of the stem or branches and in perfecting the fruit. There can be no question at all, therefore, as regards the superiority for manurial purposes of the green leaves of a particular tree over the dead leaves from the same tree. The dead leaves fall, moreover, at a particular season and have to be collected at that particular season; otherwise they soon become incorporated with the soil and disappear. If put in deep pits they would in the course of a year decompose into what is known as a leaf-mould by gardeners. This material would, in my opinion, have inferior manurial value to the manure now used. I am convinced that such would be the case from the results of analyses by the Agricultural Chemist to the Government of India of the various descriptions of green

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Cultivation of Pepper

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leaves and small twigs ordinarily used. I sent him the leaves and twigs of eight different varieties of trees, being such as are considered best for leaf-manure. The analyses are appended below :—

Analyses of leaves and twigs used.

	Careya arborea.	Bassia latifolia.	Pterocarpus Marsupium.	Xylia dolabriformis.	Terminalia Chebula.	Dillenia pentagy a.	Terminalia paniculata).	Terminalia tomentosa.
Moisture	80·66	78·95	78·77	73·31	77·77	87·06	75·06	81·86
Dry matter	19·34	21·05	21·23	26·69	22·23	12·94	24·94	18·14
Organic matter	18·00	19·60	19·58	25·24	20·90	11·68	23·42	16·74
Mineral matter	1·34	1·45	1·65	1·45	1·33	1·26	1·52	1·40
Silica	·08	·10	·12	·11	·04	·08	·12	·07
Potash (K_2O)	·43	·43	·53	·44	·30	·41	·40	·44
Phosphoric acid (P_2O_5)	·086	·087	·095	·08	·078	·070	·100	·080
Nitrogen	·31	·43	·45	·62	·40	·24	·42	·34

Analyses compared with cattle-manure.

5. The leaves and twigs contained from 73 per cent. to 87 per cent. of water. But even in this succulent condition the percentage of nitrogen and potash (the two most important elements of plant food) were equal to about half the quantities usually found in well-preserved farmyard manure. The air-dried material of these leaves and twigs would be considerably richer in nitrogen and potash than air-dried well-preserved cattle-manure. The leaves and twigs are all deficient in phosphoric acid. The contention of the gardeners that certain leaves are better manurially than others is not supported by the analyses. *Hirda* leaves are considered locally very superior for leaf-manure, also those of *matti* and *honne*. But the analyses show that other varieties are superior to these for manure purposes. On the other hand, it is fair to state that the leaves of *hirda, matti* and *honne* are considered specially valuable, because the manure produced from them destroys insects and grubs which would be harmful to the plants in the garden. These leaves and in fact nearly all the leaves used by the gardeners have astringent properties, and it is, I think, certain that vegetable matter containing astringent resins or volatile oils would be obnoxious to insects and therefore insects or grubs which might be harmful to the plants of the garden would not harbour in such material. Dry leaves, unless collected soon after they have fallen, undoubtedly harbour insect life, and this is one serious objection to their use as manure. I was hopeful that the Agricultural

Analyses do not bear out the gardeners preferences.

Reason of preference.

GREEN MANURING OF PEPPER.

Chemist would be able to state definitely how far the various leaves and twigs submitted for analyses differed in astringent properties. He was, however, unable to investigate this point. I took no samples of dead leaves, because at the time of my visit to Kánara (April) it was impossible to collect samples which could be identified as belonging to any of the particular trees from which green leaves are usually taken. In fact dead leaves had mostly disappeared by that time. I believe they mostly fall in December-January, and could not, except in trifling quantity, be collected during the monsoon when green leaves and twigs are ordinarily collected as manure.

Means of improving the green manure.

6. **Dr. Leather's** analyses clearly indicate that manure of good quality can be made from the green leaves and twigs ordinarily used. The system of trampling the leaves under the feet of cattle, so that the urine and solid excreta are absorbed would improve the quality of the manure particularly if the cattle are fed partly on cake as is sometimes the case. The storage of manure in deep pits formed in soil and subsoil, which is very retentive, can hardly be improved upon excepting that the extremely heavy rainfall of the district must keep the unprotected pits excessively wet during the monsoon, and probably valuable manurial ingredients are washed out of the manure at this season.

Frequency of application.

7. The Kánara system is to apply manure every second year.

Analysis of manures.

8. I submitted to the Agricultural Chemist to the Government of India four samples of manures. Each sample is sufficiently described in the tabulated statement below :—

	Monsoon green leaf-manure. Sample taken from roots of trees to which it was applied in February 1898.	Green leaf-manure as applied to Betel palms, February 1899. Sample taken in April 1899.	Dry leaf-manure made from dead leaves used as litter under cattle fed on grass, etc.	Manure made from green leaves collected in the rains and used as litter under cattle.
Moisture . .	55·07	58·05	56·90	59·72
Dry matter . .	44·93	41·95	43·10	40·28
Organic matter .	23·44	28·74	25·42	26·48
Mineral matter .	21·48	13·21	17·68	13·80
Sand . . .	14·69	7·80	11·43	7·47
Potash (K_2O) .	·16	·41	·43	·17
Phosphoric acid (P_2O_5) . .	·14	·18	·12	·17
Nitrogen . .	·51	·51	·55	·75

PIPER nigrum.

Cultivation of Pepper

GREENING MANURING OF PEPPER

It is difficult to understand the deficiency of potash in the 4th sample. The nitrogen and phosphoric acid are probably about average for this kind of manure. Samples Nos. 1 and 2 were originally of similar class to sample No. 4. They were, I imagine, superior in quality originally to No. 4. No. 1 sample (taken in handfuls from many trees) is by no means exhausted 14 months after application, and it may be inferred from this that the gardener's methods of application and of protecting the manure from surface wash and heavy rainfall by a covering of branch-wood and leaves are successful in practice. From personal observation, I can say that the branch-wood, a full year after being first put on, is sufficient to break the force of heavy downpours of rain, and when first put on or afterwards allows the rainfall to percolate through the manure to feed the plants. It is suggested in the papers by one officer that the gardeners should use the leaf-sheaths of the *supári* palm (**Areca Catechu**, *Linn.*,) leaves as a protection for the manure instead of the branch-wood now used. The leaf-sheaths are all required for another purpose in the garden economy, and in any case the manure does not (as **Mr. Davidson** points out) need a water-proof. It needs protection and needs also to soak up the rainfall, as it falls in a fair and reasonable way.

Slow exhaustion of green manure under protection of branch-wood.

9. No. 2 sample was taken in the same way as No. 1 in handfuls from above the roots of many trees. The samples were taken two months after application. No. 2 contains less sand than No. 1 for obvious reasons, and probably its original manurial elements had been since application utilized to considerable extent, as the trees and plants were in active growth. The garden soil and the manure were quite moist, and there had been rather abnormal heavy rainfall some little time before the samples were taken. These are conditions which would help the plants to utilize the manurial ingredients quickly. The sample No. 3 from dry leaves used as litter under cattle is quite as good as might be expected. It has about half the manurial value of good cattle dung manure. The owner considered it was poor stuff. The high percentage of sand is noticeable.

Success of the present expensive system.

10. There is no doubt that the present system of manuring in the Kánara Gardens is successful in practice, provided the gardeners are allowed to use in sufficient quantity the kinds of forest produce which they prefer. The system of manuring is expensive, even

ALTERNATIVES.

though the materials are got free, and the destruction caused to forest growth is enormous. Under the circumstances, it would, I think, be most advisable to test by experiment whether available concentrated manures, such as castor cake or safflower cake, could take the place of a portion of the manure now used. These cakes can be imported from Dhárwár at reasonable rates into the district. Castor cake is less valuable manurially than safflower cake, and is dearer. In the Gardens of Bassein, with heavy rainfall in light soil, castor cake is successfully used. It is obnoxious to insect life, and if used in the Kánara gardens there would probably be less damage done by grubs and borers, which certainly do considerable damage to the garden plants and trees now.

ANALYSES OF PEPPER SOILS.

11. I append hereto analyses by Dr. Leather of samples of four descriptions of soils which are sufficiently described in the appended tabular statement :—

	Kagadali earth, *e.g.*, the earth excavated from embankments and carried in head-loads to renew the garden soil of old-established garden when renewal is required.	Earth from rice beds near a thriving spice garden and similarly situated to the garden and presumably capable of being converted into garden.	Soil from old-established gardens.	Soil from new extension of an old garden.
Lime (CaO) total .	·11	·09	·15	·19
Magnesia (MgO) total . . .	·30	·30	·29	·38
Alkalies total . .	1·07	·31	...	...
Potash total . .	·154	·071	·110	·27
Potash (K_2O) available	·003	·008	·004	·005
Phosphoric acid (P_2O_5) total . .	·086	·04	·073	·074
Phosphoric acid available . .	·001	·0017	·0005	·0015
Nitrogen total . .	·014	·20	·09	·18
Nitric acid (as Nitrates) . .	·0009	*Nil.*	*Nil.*	·003

Needs of the soil.

12. Dr. Leather says the samples are all deficient in lime phosphoric acid and more or less so in available potash. I should, as a matter of fact, class them as agriculturally poor, but in my extended notes regarding the garden cultivation I remarked that it does not matter much whether the garden soil is naturally fertile or not, because the yield of the crops is mostly affected by the quality and quantity of manure given. As regards the soil it must be of such consistence that

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PIPER nigrum.

Cultivation of Pepper in the Bombay Presidency.

MANURIAL NEEDS OF PEPPER SOILS.

it withstands the denuding effect of flood water and be so retentive of moisture that little or no irrigation is required in the fair season. All the samples submitted to Dr. Leather possessed these desirable qualities. It has already been shown that the leaves and twigs used by the cultivators are rich in potash and also in nitrogen, in which the soils are decidedly deficient. It has also been shown that the trampling of the leaves under cattle and the absorption of the excreta particularly, if the cattle are partially fed on cake, improves the resultant manure in phosphates. Dr. Leather has not separately estimated the amount of lime in the manures, but he shows that the soils are deficient in this important ingredient. I have already stated that the *matti* tree when burnt leaves an ash rich in lime, or, according to local opinion, it yields *chunam*. The cultivators are specially anxious to be allowed to take the leaves and twigs of this tree. If the manure applied to the trees in the Kánara gardens was mixed, as in common agricultural practice, freely with the soil, then the soil in old-established gardens would probably be richer in manurial ingredients than new soil.

Conclusion.

13. I conclude from a study of Dr. Leather's analysis that the system of manuring, as practised in the gardens of Kánara, is as right in theory and practice as it well can be, provided the manure as it accumulates in the pits is subjected in the least possible degree to the wasteful wash of the heavy Kánara rainfall.

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THE NATURE, VALUE AND UTILISATION OF ALKALI LANDS.

By E. W. HILGARD, ESQ., *Director of the Agricultural Experiment Station, College of California, U. S. A. With a Prefatory Note and Appendix by* The Editor.

INTRODUCTORY.

In October 1895, the Director, Royal Gardens, Kew, very kindly furnished the Reporter on Economic Products with a copy of a paper by Messrs. E. W. Hilgard and R. H. Loughbridge on "The Distribution of the Salts in Alkali Soils" being Bulletin No. 108 of the Agricultural Experiment Station, University of California, published in August 1895.

That paper was, with the authority of the Government of India, reproduced in *The Agricultural Ledger*, No. 1 of 1896.

The Board of Revenue, Madras, have now drawn attention to a fuller statement of the opinion of Professor E. W. Hilgard as published in Bulletin of the Agricultural Experiment Station of the University of California, No. 128, which was issued in 1900. The first 21 pages of the new Bulletin had, however, appeared in the Year-Book of the United States Department of Agriculture for 1895, and has thus very possibly been seen by most of the readers of *The Agricultural Ledger*.

At the suggestion of the Board of Revenue, Madras, it is, therefore, proposed to review here very briefly Professor Hilgard's revised paper on this subject so as to bring out the interesting additional particulars that have a possible bearing on the Indian problem of Reh efflorescence, in amplification of what has been already published in *The Agricultural Ledger*, No. 1 of 1896.

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DISTRIBUTION OF ALKALI LANDS IN THE WORLD.

On the Distribution of Alkali Lands (*pp.* 4-5).

"In looking over a rainfall map of the globe," says Professor Hilgard, "we see that a very considerable portion of the earth's surface has deficient rainfall, the latter term being commonly meant to imply any annual average less than 20 inches (500 millimetres). The arid region thus defined includes in North America, most of the country lying west of the one hundredth meridian up to the Cascade Mountains, and northward beyond the line of the United States; southward, it reaches far into Mexico, including especially the Mexican plateau. In South America it includes nearly all the Pacific Slope (Peru and Chile) south to Araucania; and eastward of the Andes, the greater portion of the plains of Western Brazil and Argentina. In Europe only a small portion of the Mediterranean border is included; but the entire African coast-belt opposite, with the Saharan and Libyan deserts, Egypt and Arabia, are included therein as well as a considerable portion of South Africa. Asia Minor, Syria (with Palestine), Mesopotamia, Persia, and North-Western India up to the Ganges, and northwards, the great plains or steppes of Central Asia, eastward to Mongolia and Western China, fall into the same category; as does also a large portion of the Australian Continent.

"Over these vast areas alkali lands occur to a greater or less extent, the exceptions being the mountain regions and adjacent lands on the side exposed to prevailing oceanic winds. It will, therefore, be seen that the problem of the utilisation of alkali lands for agriculture is not of local interest only, but is of world-wide importance. It will also be noted that many of the countries referred to are those in which the most ancient civilisations have existed in the past, but which at present, with few exceptions, are occupied by semi-civilised people only. It is doubtless from this cause that the nature of alkali lands has until now been so little understood that even their essential distinctness from the sea-border lands has been but lately recognised in full. Moreover, the great intrinsic fertility of these lands has been very little appreciated, their repellant aspect causing them to be generally considered as waste lands.

"This aspect is essentially due to their natural vegetation being in most cases confined to plants useless to man, commonly designated as 'saline vegetation' of which but little is usually relished by cattle.

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DISTRIBUTION OF ALKALI LANDS IN THE WORLD.

Notable exceptions to this rule occur in Australia and Africa, where the 'salt-bushes' of the former and the 'karroo' vegetation of the latter form valuable pasture grounds. Apart from these, however, the efforts to find for these lands, while in their natural condition, culture plants generally acceptable, or at least profitable, outside of forage crops, have not been very successful."

Professor **Hilgard** here illustrates by actual statistical returns and maps (very similar to those already given in *The Agricultural Ledger*, No. 1 of 1896, pages 4*a*, 4*b*, 4*c*), the following subjects, *viz.*, "How Plants are Injured by Alkali," "The Effects of Irrigation," "Determination of the Distribution of the Alkali Salts," and "Composition of Alkali Salts," and thereafter gives the following—

GENERAL CONCLUSIONS (pp. 13-14).

GENERAL CONCLUSIONS.

"Summing up the conclusions from the foregoing observations and considerations we find that—

(1) "The amount of soluble salts in alkali soils is usually limited; they are not ordinarily supplied in indefinite quantities from the bottom water below. These salts have essentially been formed by weathering in the soil layer itself.

(2) "The salts ordinarily move up and down within the upper 4 or 5 feet of the soil and sub-soil, following the movement of the moisture; descending in the rainy season to the limit of the annual moistening as a maximum and then re-ascending or not according as surface evaporation may demand. At the end of the dry season in untilled irrigated land, practically the entire mass of salts may be within 6 or 8 inches of the surface.

(3) "The injury to vegetation is caused mainly, sometimes wholly, within a few inches of the surface, by the corrosion of the bark, usually near the root crown. This corrosion is strongest when carbonate of soda (salsoda) forms a large proportion of the salts; the soda then also dissolves the vegetable mould, and causes blackish spots in the soil, popularly known as black alkali.

(4) "The injury caused by carbonate of soda is aggravated by its action in puddling the soil so as to cause it to lose its

GENERAL CONCLUSIONS.

flaky condition, rendering it almost or quite untillable. It also tends to form in the depths of the soil layer a tough hard pan, impervious to water, which yields to neither plough, pick, nor crowbar, and renders drainage and leaching impossible. Its presence is easily ascertained by means of a pointed steel-sounding rod.

(5) "While alkali lands share, with other soils of the arid region, the advantage of unusually high percentages of plant-food in the insoluble form, they also contain alongside of the noxious salts considerable amounts of water-soluble plant-food. When, therefore, the action of the noxious salts is done away with, they should be profusely and lastingly productive; particularly as they are always naturally somewhat moist in consequence of the attraction of moisture by the salts, and are, therefore, less liable to injury from drought than the same soils when free from alkali."

Professor Hilgard, in the pages that here follow in his revised paper up to page 22, deals with the "Utilisation and Reclamation of Alkali Lands," "Chemical Remedies," "Removal of Salt from the Soil" and with the answers to the question "Will it pay to Reclaim Alkali Lands." The Professor's views on these various topics have, for the present purpose, been sufficiently indicated by pages 2-7 of *The Agricultural Ledger*, No. 1 of 1896. But the final conclusion on the topic of whether or not it will pay to reclaim alkali lands may be here given, since it leads up very naturally to the subject of the crops suitable as agents of reclamation:—

Will reclaiming pay?

"It does not of course follow that alkali lands are good lands for farmers of limited means to settle upon. On the contrary, like most other business enterprises they require a certain amount of capital and lapse of time to render them productive. They are not, therefore, a proper investment for farmers or settlers of small means dependent on annual crops for their livelihood and unable to bring to bear upon these soils the proper means for their reclamation; unless indeed, local conditions should enable them to use successfully some of the crops specially adapted to alkali lands."

As explained above, the new material which Professor Hilgard has given to the public may be said to be his remarks on the crops

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GENERAL CONTENTION THE SAME IN INDIA AND IN NORTH AMERICA.

suitable for alkali lands, namely, pages 22 to 46 of the new report. Many of the plants mentioned on these pages are either unknown to Indian cultivators or quite unsuited to Indian agriculture. Still the general contention would not be fully shown were these omitted.

I propose accordingly to quote the Professor's remarks in full, omitting only the interesting plates which greatly enhance the value of the original. The cost of reproduction would, however, from the Indian standpoint greatly exceed their value. By way of emphasizing Professor Hilgard's observations, I shall then conclude by reviewing all the available Indian information on the wild or cultivated plants that have a reputation of being suitable for reclamation of reh efflorescent soils.

CROPS SUITABLE FOR ALKALI LANDS (pp. 22-46).

CROPS SUITABLE IN NORTH AMERICA.

"As has already been stated, the search for generally available crops that will thrive in strong unreclaimed alkali land has not thus far been very successful. It is true that cattle will nibble alkali grass (**Distichlis spicata**), but will soon leave it for any dry feed that may be within reach. The same is true of all the fleshy plants that grow on the stronger alkali lands and are known under the general designation of alkali weeds. When stock unaccustomed to it are forced by hunger to feed on such vegetation to any considerable extent, disordered digestion is apt to result; which in such ranges, however, is often counteracted by feeding on aromatic or astringent antidotes, such as the gray sage-brush, and the more or less resinous herbage of plants of the sunflower family. In the Great Basin region lying between the Sierra Nevada and the front range of the Rocky Mountains, there are, aside from the grasses, numerous herbaceous and shrubby plants that afford valuable pasturage for stock, and some of these grow on moderately strong alkali land; the same is true in California. It is quite possible that some of these will be found to lend themselves to ready propagation for culture purposes as well as they do for re-stocking the ranges. But thus far none have found wider acceptance, probably because their stiff branches and upright habit render them inconvenient to handle. It will require more extended experience and experiment before any of these can be definitely adopted by farmers.

"Experience in California indicates that in the more southerly portion of the arid region the unpalatable native plants may be

CROPS SUITABLE IN NORTH AMERICA.

generally replaced, even on the ranges, by one or more species of the Australian salt bushes (**Atriplex** spp.), long ago recommended by Baron von Mueller of Melbourne; of which one (**A. semibaccata**) has proved eminently adapted to the climate and soil of California and is readily eaten by all kinds of stock. The facility with which it is propagated, its quick development, the large amount of feed yielded on a given area, even in the strongest alkali land ordinarily found, and its thin flexible stems, permitting it to be handled very much like alfalfa (**Medicago sativa**), seem to commend it specially to the farmer's consideration wherever the climate will permit of its use. Its resistance to severe cold weather has not yet been adequately tested. It is probable that other species, now also under trial, will equally justify the recommendation given them by the eminent botanist who first brought them into public notice as promising forage plants. Most of the species have an upright, shrubby habit, which adapts them rather to browsing than to use as a forage crop. Among the best, next to the **semibaccata**, are the species **leptocarpa** and **halimoides**, the former somewhat similar in habit to the **semibaccata**, but not so rapid a grower."

"It is to be noted that since the salt-bushes take up nearly one-fifth of their dry weight of ash ingredients, largely common salt, the complete removal from the land of a five-ton crop of salt-bush hay will take away nearly a ton of the Alkali salts per acre. (Analyses made at the California Station show 19·37 per cent. of ash in the air-dry matter of Australian salt-bush. Analyses of Russian thistle (**Salsola Kali** *var.* **Tragus**) have been reported showing over 20 per cent. of ash in dry matter). This will in the course of some years be quite sufficient to reduce materially the saline contents of the land, and, will frequently render possible the culture of ordinary crops.

"Next to the salt-bushes the Chilian plant **Modiola decumbens** (now commonly known as 'modiola' simply), of the mallow family, deserves attention. Accidentally introduced as a weed with other seeds, by the Keror County Land Company at Bakersfield, it attracted attention by its persistence on alkali lands, and by the observation that cattle ate it freely. It was then grown on a larger scale, and found to make acceptable pasture where alfalfa could not be grown on account of alkali. It is a trailing plant with medium-sized roundish foliage, and roots freely at the joints where they touch the

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CROPS SUITABLE IN NORTH AMERICA.

ground. Unlike the salt-bushes it is, therefore, a formidable weed where it is not wanted; but as, according to our determinations, it resists as much as 52,000 pounds of salts per acre, even when 41,000 of these is common salt, it is likely to be useful in many cases, particularly as an admixture to a salt-bush diet for stock, the more as it does not absorb as much salt as the latter. Owing to the rooting habit of the stems, it is not as convenient to handle as the **semi-baccata** salt-bush, nor, probably, will it yield as much fodder in a season. It seems best adapted to pasturage.

"Another forage plant which it may hereafter pay to propagate artificially on strong alkali land is the tussock-grass **(Sporobolus airoides)**. Indicating as it usually does when growing naturally, land too strongly impregnated to be reclaimable at this time, but being eaten freely by stock, it seems worth while to count it among the possible pasture grasses for land too strongly alkaline to bear ordinary crops. Its seed can be abundantly gathered in its native habitats indicated below.

AMOUNT OF SALTS COMPATIBLE WITH ORDINARY CROPS.

LIMIT OF SALINITY FOR VARIOUS CROPS.

Since the amount of alkali that reaches the surface layer is largely dependent upon the varying conditions of rainfall or irrigation and surface evaporation, it is difficult to foresee to what extent that accumulation may go, unless we know the total amount of salts present that may be called into action. This can be ascertained by a summation of the results obtained, but more readily by the examination of one sample representing the average of the entire soil column of 4 feet. By calculating the figures so obtained to an acre of ground, we can at least approximate the limits within or beyond which crops will succeed or perish.

Grain crops.

Grasses.—Applying this procedure to the cases investigated at the Tulare sub-station, and estimating the weight of the soil per acre-foot at 4,000,000 pounds, we find for the land on which *barley* refused to grow the figures 32,480 pounds of total salts per acre, corresponding to 0·203 per cent.; while for the land on which barley gave a full crop we find 25,440 pounds, equivalent to 0·159 per cent. for the whole soil column of 4 feet. It thus appears that for barley the limits of tolerance lie between the above two figures, which might, of course, have been obtained equally well from an average sample of

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LIMIT OF SALINITY FOR VARIOUS CROPS.

the 4-foot column by making a single analysis. It should be noted that in this case a full crop of barley was grown even when the alkali consisted of fully one half of the noxious carbonate of soda, proving that it is not necessary in every case to neutralise the *entire* amount of that salt by means of gypsum, which in the present case would have required about 9½ tons of gypsum per acre—a prohibitory expenditure.

"Rye appears to be about like barley in its tolerance of alkali salts; while wheat is somewhat more sensitive. In fact the superficial rooting and fine fibrous roots of the true grasses render them, as a whole, rather sensitive to alkali salts; yet there are a number of the perennial kinds whose thick roots and deeper rooting render them measurably resistant. Aside from the alkali grass proper **(Distichlis),** the so-called rye-grass of the North-West **(Elymus condensatus)** is probably, next to the tussock-grass, the most resistant species among the wild grasses. Its southern form, with several others not positively identified, occupy largely the milder alkali lands of Southern California, such as the low lands near Chino, producing choice sugar beets on a close-textured silty loam.

"While maize is rather sensitive, and fails on even slightly alkaline lands, Egyptian corn and other sorghums, rooting somewhat deeper, and having stout roots do well on mild alkali soils of the white class. The same appears to be true of some of the stout-rooted millets, such as barnyard grass **(Panicum Crus-galli),** of which the variety (?) **muticum** is reported to succeed in neutral alkali land. One of the most successful grasses on the light alkali lands near Chino, where most of the commonly cultivated kinds fail, was a near relative of the barnyard grass, the **Eleusine Coracana,** which produces heavy crops of a millet-like grain much relished by poultry and also by stock. This grass has succeeded all over the ground whose alkali content ranges up to 12,000 pounds per acre. Next to this, in point of success, were the pearl millet **(Pennisetum typhoideum)** and teosinte, Hungarian brome grass, and Japanese millet, on land containing about 9,000 pounds of salts per acre. The loliums, including the darnel ('California cheat' **Lolium temulentum)** and the Australian and Italian ray ('rye') grasses **Lolium perenne,** succeed fairly on land containing as much as 6,000 pounds of (white) salts. Most other cultivated grasses failed conspicuously alongside

Fodder crops,

LIMIT OF SALINITY FOR VARIOUS CROPS.

of these. It must be remembered that in more loose-textured sandy lands than those in which these tests were made, the above figures for tolerance would probably be increased by 30 per cent. or more.

" Doubtless some of the indigenous grasses of the interior plateau region and the great plains east of the Rocky Mountains, such as the buffalo and grama grasses, as well as several of the wheat grasses **(Agropyron)** and bunch grasses **(Festuca, Poa, Stipa,** etc.) will prove resistant to larger proportions of alkali than the meadow and pasture grasses of the regions of summer rains.

" ***Legumes.***—Both the natural growth of alkali lands and experimental tests seem to show that this entire family (peas, beans, clovers, etc.) are among the more sensitive and least available wherever black alkali exists, while fairly tolerant of the white (neutral) salts. Apparently a very little salsoda suffices to destroy the tubercle-forming organisms that are so important a medium of nitrogen-nutrition in these plants, alfalfa, with its hard, stout and long tap root, seems to resist best of all these plants, excepting the melilots. As a general thing, tap-rooted plants, when once established, resist best, for the obvious reason that the main mass of their feeding roots reaches below the danger level. Another favouring condition, already alluded to, is heavy foliage and consequent shading of the ground; alfalfa happens to combine both of these advantages. There has been some difficulty in obtaining a full stand of alfalfa in the portion of the Chino tract containing from 4,000 to 6,000 pounds of alkali salts per acre, but once obtained it has done very well. The only other plant of this family that succeeds well on this land and even (at Tulare) on soil considerably stronger (probably between 20,000 and 30,000 pounds) are the two melilots, **Melilotus indica** and **alba**; the latter (the Bokhara clover) is a forage plant of no mean value in moist climates, but somewhat restricted in its use in California because of the very high aroma it developes, especially in alkali lands, so that stock will eat only limited amounts, except when intermixed with other forage, such as the salt-bushes. The yellow melilot is highly recommended by the Arizona station as a green manure plant for winter growth; but in this state it is a summer-growing plant only, and is refused by stock. Very few plants belonging to this family are naturally found on alkali lands, and attempts to grow them, even where only glauber salt is present, have been but very moderately

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LIMIT OF SALINITY FOR VARIOUS CROPS.

successful. The salts seem to retard or even prevent the formation of the tubercles useful for nitrogen absorption: and for most of the legumes the limit of full success seems to lie between 3,000 and 4,000 pounds to the acre.

Miscellaneous plants.

"***Weeds.***—Like the legumes, wild plants of the mustard family are rare on alkali lands; and correspondingly, the cultivated mustard, kale, rape, etc., fail even on land quite weak in alkali. Their limit of tolerance seems to lie near 4,000 to 5,000 pounds per acre of even white salts.

"Several of the hardiest of the native 'alkali weeds' belong to the sunflower family, and the common wild sunflowers (**Helianthus californicus** and **H. annuus**) are common on lands pretty strongly alkaline. Correspondingly, the 'Jerusalem artichoke,' itself a sunflower, is among the available crops on moderately strong alkali soils; and so, doubtless, are other members of the same relationship not yet tested, such as the true artichoke, salsify, etc. Chicory, belonging to the same family, yielded roots at the rate of 12 tons per acre on land on the Chino tract containing about 8,000 pounds of salts per acre.

Root crops.

"***Root Crops.***—It seems to be generally true that root crops suffer in quality, however satisfactory may be the quantity harvested on lands rich in salts, and especially in chloride (common salt). It was noted at the Tulare sub-station that the tubers of the artichoke were inclined to be 'squashy' in the stronger alkali land, and failed to keep well; the same was true of potatoes, which were very watery; and also of turnips and carrots. It is a fact well known in Europe, that potatoes manured with kainit (chlorides of potassium and sodium) are unfit for the manufacture of starch, and are generally of inferior quality. But this is found not to be the case when, instead of the chloride, the sulphate is used; hence the advice often repeated by this station, that farmers desiring to use potash fertilisers should call for the 'high-grade sulphate' instead of the cheaper kainit, which adds to the injurious salts already so commonly present in California lowland soils.

"The common beet (including the mangel-wurzel) is known to succeed well on saline seashore lands, and it maintains its reputation on alkali lands also. Being specially tolerant of common salt it may be grown where other crops fail on this account; but the roots so

grown are strongly charged with common salt, and have, as is well known, been used for the purpose of removing excess of the same from marsh lands. Such roots are wholly unfit for sugar-making.

LIMIT OF SALINITY FOR VARIOUS CROPS.

"It is quite otherwise with glauber salt (sodium sulphate); and as this is usually predominant in alkali lands, either before or after the gypsum treatment, this fact is of great importance, for it permits of the successful growing of the sugar beet; as has been abundantly proved at the Chino ranch, where land containing as much as 12,000 pounds of salts, mostly this compound, has yielded roots of very high grade both as to sugar percentage and purity.

Vegetable crops.

"Asparagus is another crop which bears considerable amounts of common salt as well as glauber salt; but not of salsoda, which must first be transformed by the use of gypsum.

"Rhubarb was a conspicuous failure in even the weak alkali lands of the Chino tract.

Textile plants.

"***Textile Plants.***—Japanese hemp seemed to have a hard struggle with the alkali while young, but at the end of the season stood 8 feet high. The ramie plant, also, will bear moderately strong alkali, apparently somewhat over 12,000 pounds per acre. Flax has not been tested in cultivation; but its wide distribution all over the States of Oregon and Washington would seem to indicate that it is not very sensitive. Another textile plant, the Indian mallow **(Abutilon avicennæ)** was found to fail on the Chino alkali soil.

Grapes.

"***Grapevines.***—**Vitis vinifera** is quite tolerant of white or neutral alkali salts, and will resist even a moderate amount of the black so long as no hardpan is allowed to form. At the Tulare sub-station, it was found that grapevines did well in sandy land containing 35,230 pounds of alkali salts, of which one half was glauber salt, 9,640 pounds carbonate of soda, 7,550 pounds common salt, and 750 pounds nitrate of soda. They were badly distressed where, of a total of 37,020 pounds of alkali salts, 25,620 pounds was carbonate of soda; while, where the vines had died out, there was found a total of 73,930 pounds, with 37,280 pounds of carbonate. The European vine, then, is considerably more resistant of alkali even in its worst (black) form, than barley and rye; and it seems likely that the native grapevines of the Pacific Coast, **Californica** and **Arizonica**, would resist even better; a point still under experiment.

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LIMIT OF SALINITY FOR VARIOUS CROPS.

"Experience, however, has shown that vines rapidly succumb when by excessive irrigation the bottom water is allowed to rise, increasing the amount of alkali salts near the surface and shallowing the soil at their disposal. Such over-irrigation has been a fruitful cause of injury to vineyards in the Fresno region, and would doubtless, if practised, kill most of the vines at Tulare sub-station which are now flourishing. In such cases sometimes the formation of hardpan is followed by that of a concentrated alkaline solution above it, strong enough to corrode the roots themselves, and not only killing the vines, but rendering the land unfit for any agricultural use whatsoever. The swamping of alkali lands, whether of the black or white kind is not only fatal to their present productiveness, but, on account of the strong chemical action thus induced, greatly jeopardises their future usefulness. Many costly investments in orchards and vineyards have thus been rendered unproductive, or have even become a total loss.

Oranges, etc.

"***Citrus Trees.*** - These are *on the whole* rather sensitive to alkali, especially while young; so that it is often difficult to obtain a stand even when later on, the feeding roots descend beyond the reach of injury. In the close-textured lands of Chino, young trees hardly maintained life with more than 5,000 pounds of total salts. Common salt seems to be particularly injurious; near Riverside, full-grown trees perished under the influence of bottom water containing 0·25 per cent. or 146 grains of salt per gallon, which impregnated the ground; corresponding to about 9,000 pounds per acre in four feet."

"In the sandy loam lands near Corona, trees eight years old suffered severely when by irrigation with alkali water the alkali content of the land reached 11,000 pounds per acre; at another point in the same region, two representative trees were selected for comparison, five rows apart on land absolutely identical; one of these retained its leaves, though suffering, the other was completely leafless. The leaching of the alkali to the depth of 4 feet gave the following results, calculated to pounds per acre:

	Sulphates.	Carbonates.	Chlorides.	TOTAL.
Poor tree .	4,720	1,680	2,520	8,920
Better tree .	4,120	2,360	720	7,200

"Here it is apparently the excess of common salt to which the difference is due, and this despite the higher content of carbonate of soda in the soil bearing the better tree.

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LIMIT OF SALINITY FOR VARIOUS CROPS.

"On the other hand, at the Tulare sub-station, orange trees (sour stock) maintain vigorous growth and good bearing in a very sandy tract which to the depth of 7 feet showed an aggregate content of 26,840 pounds of salts (or 22,780 to 4 feet depth); but which is never irrigated. The salts in this case consist wholly of *sulphate* and *carbonate of soda* in the ratio of 54 to 42, implying the presence of nearly 12,000 pounds of salsoda within reach of the tree-roots; yet in the absence of common salt, no perceptible injury or even stress upon the trees has been noted.

"In view of these facts, it seems that common salt is the portion of alkali by far most injurious to citrus trees, and great care should be taken in the use of irrigation waters to exclude those charged with common salt; also to avoid locating citrus orchards where common salt pre-exists in the land.

Orchard trees.

"***Deciduous Orchard Trees.***—Of these, strangely enough, the almond seems to resist best. The peach is more sensitive; the apricot does fairly. Plum trees as such are nearly as resistant as peaches, but sometimes suddenly begin to fail when beginning to bear; the fruit appears normal on the outside for a time, but the pit fails to form, being sometimes flattened out like a piece of paste-board; and the fruit fails to mature. Apples are rather sensitive; pears considerably less so, doing well even when the outside bark around the root crown is blackened by the alkali. The olive is quite resistant; the fig less so. The English walnut resents even a slight taint of black alkali, but is fairly tolerant of 'white' salts, as is shown in the peculiarly suitable light loam soils on the lower Santa Clara River in Ventura County.

"Figures for the limits of alkali tolerance in the case of the deciduous orchard trees have not yet been closely determined, owing to the difficulties inherent in the differences of root penetration in the several soils and localities. On the ten-acre tract near Chino, therefore, on a rather close-textured soil, apple trees have done very well on land containing one-fourth of one per cent. of 'white' salts, or between 10,000 and 11,000 pounds per acre.

Trees.

"***Timber and Shade Trees.***—Of trees suitable for alkali lands, two native ones call for mention. One is the California white or valley oak **(Quercus lobata)**, which forms a dense forest of large trees on the delta lands of the Kaweah River in California, and is found scatteringly all over the San Joaquin Valley.

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LIMIT OF SALINITY FOR VARIOUS TREES.

Unfortunately this tree does not supply timber valuable for aught but firewood or fence posts, being quite brittle. The native *cotton woods*, while somewhat retarded and dwarfed in their growth in strong alkali, are quite tolerant of the white salts, especially of glauber salt.

"Of other trees, **Platanus orientalis,** the oriental plane or sycamore, and the black locust, have proved the most resistant in the alkali lands of the San Joaquin Valley; and the former being a very desirable shade tree, it should be widely used throughout the regions where alkali prevails more or less. The ailantus is about equally resistant, and but for the evil odour of its flowers, deserves strong commendation. Of the eucalypts, the narrow-leaved **Eucalyptus amygdalina** (one of the 'red gums') seems to be least sensitive, and in some cases has grown as rapidly as anywhere. **E. rostrata,** as well as the pink-flowered variety of **E. sideroxylon** are now doing about as well as the **amygdalina** at Tulare where at first they seemed to suffer. The common blue gum, **E. globulus,** is much more sensitive.

"Of the acacias the tall-growing **A. melanoxylon** ('black acacia') resists pretty strong alkali, even on stiff soil; as can be seen at Tulare and Bakersfield, where there are trees nearly two feet in diameter. The beautiful A. **lophantha (Albizzia)** has in plantings made along the San Joaquin Valley Railroad shown considerable resistance likewise; but it is quite sensitive to frost.

"One of the 'Australian pines,' **Casuarina equisetifolia,** was transplanted experimentally on station grounds of the Valley Railroad from the Chico forestry sub-station, and a number are growing very well in alkali lands. This tree is credited by Maiden with being tolerant of 'saline soil.' Doubtless many others of the **Casuarina** tribe will be found similarly resistant.

"Of Eastern trees, the elms have done fairly well, but the tulip tree, the linden, the English oak, and most other trees of the Atlantic States, became stunted. Among those doing fairly well is the honey locust; but its thorns and imperfect shade render it not very desirable.

"The California maple **(Acer macrophyllum)** and box elder **(Negundo californica)** have done fairly well in the lighter alkali lands at Tulare.

"A most remarkably alkali-resistant shrub or small tree is the pretty **Koelreuteria paniculata,** which at Tulare is growing in some of the strongest alkali soil of the tract. Unfortunately it is

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available mainly for ornamental purposes; its wood, while small, is very hard and makes excellent fuel.

IRRIGATION WITH SALINE WATERS.

IRRIGATION WITH SALINE WATERS.

"It would hardly seem necessary to emphasize specially the danger incurred in irrigation with waters containing unusual amounts of soluble salts; since ordinary common sense clearly indicates the impropriety of increasing the saline contents of soils already charged with them, by the evaporation, year after year, of large masses of saline water. Yet experience has shown that the eagerness to utilise for irrigation whatever water happens to be convenient to good lands often overcomes both that sense and the warning given by the published analyses of such waters. Without specifying localities, it may be said that great injury has already been done in California by the disregard of obviously needful caution in this respect. The very slight taste possessed by glauber salt and salsoda does not adequately indicate their presence even when in injurious amounts; so that frequently a chemical test of the waters is the only definite guide. A few general rules, however, will help to enable the irrigator to determine whether or not such examination is called for.

Great injury may be done.

"It may be taken for granted that *the waters of all lakes having no regular outflow are unfit for regular irrigation use*; since they must needs contain all the accumulations of salts from the secular evaporation of the waters that flow into them.

"The plates annexed* exhibit the cultural results of several years' irrigation with the waters of Lake Elsinore, Riverside County, as compared with the growth of orange trees on the same land, but irrigated with artesian water. Lake Elsinore is fed by the San Jacinto River and in wet years sometimes overflows for a few weeks into Temescal Creek. Thus its saline content varies somewhat, from about 80 to over 100 grains per gallon, of salts containing three-fifths of common salt and one-fifth each of glauber salt and carbonate of soda. The latter, as already stated, tends to form a hardpan in the sub-soil, and such hardpan was actually formed where the water was used; and afterwards prevented its proper penetration, so that the trees suffered from dryness of their lower roots, while damaged by the alkali salts near the surface. As mentioned before, experience elsewhere has shown that citrus trees are especially sensitive to common salt.

* Not reproduced.

REH. The Nature, Value and Utilisation

SOURCES OF GOOD WATER FOR IRRIGATION IN CALIFORNIA.

"The investigations made by the Station have, moreover, shown that aside from the frequently saline character of the well and even the artesian waters of the petroleum-bearing region of the State in the coast ranges, the streams of that region, especially the smaller ones, are sometimes too strongly charged with 'alkali' (in this case largely the sulphates of soda and magnesia) to be suitable either for irrigation or domestic use. Toward the end of the dry season, even the larger streams of the Southern coast ranges, with their diminished flow, sometimes show an excess of salts. This seems also to be true of the San Jacinto River which feeds Elsinore Lake.

"The waters flowing from the Sierra Madre, south of the Teha chapi range, are throughout of excellent quality for irrigation purposes; as are all those flowing from the Sierra Nevada. The same is true of the artesian waters of the valley of Southern California, from Los Angeles east to Redlands, and of all the deeper borings of the Antelope Valley.

"In the Great Valley, the artesian waters vary greatly in quality. Those of Kera and Tulare counties are mostly good, sometimes exceptionally so, as in the case of the water-supply of Tulare city. It is only the shallower borings, near the borders of Tulare Lake, that some waters strongly charged with carbonate of soda or other salts have been found. From Fresno and Merced we have few data as yet; but it seems that north of a line drawn from North-Eastern Stanislaus *viâ* Tracy to Point of Timber, saline waters, sometimes accompanied by some gas, occur at certain levels. But the deep wells bored at Stockton and Sacramento, and northward, have good potable water.

WHEN A WATER-SUPPLY IS TOO SALINE FOR USE.

"***Limits of Saline Contents.***—Unfortunately it is not easy to give absolute rules in regard to the exact figures that constitute an excess of salts for irrigation purposes, since not only the composition of the salts, but also the nature of the land to be irrigated, and the frequency of irrigation required, must be taken into consideration.

"Broadly speaking, the extreme limits of mineral content usually assigned for potable waters, *viz.*, 40 grains per gallon, also applies to irrigation waters. Yet it sometimes happens that all or most of the solid content is gypsum and epsom salt; when only a large excess of the latter would constitute a bar to irrigation use. When, on the contrary, a large proportion of the solids consists of carbonate of soda or of common salt, even a smaller proportion of salts than

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WHEN A WATER-SUPPLY IS TOO SALINE FOR USE.

40 grains might preclude its *regular* use, depending upon the nature of the soil to be irrigated. For, in a clay loam, or a heavy adobe not only do the salts accumulate nearer to the surface, but the sub-drainage being slow and imperfect (unless under-drained), it becomes difficult or impossible to wash out the saline accumulations from time to time as is feasible in sandy lands. In these, moreover, as already stated, the alkali never becomes as concentrated near the surface as in heavier soils. Again where *hardpan* exists in sandy land saline irrigation-water soon saturates the soil mass above it with salts. During the two dry seasons just past saline waters have frequently been used, exceptionally, in order to save trees threatened with death from drought. The Station has even advised that this should be done, with the proviso that *the salts so introduced must be washed into the sub-drainage by heavy irrigation*, whenever practicable, even if the same saline water should have to be used for the purpose. For few such waters are sufficiently strong to injure vegetation *until concentrated by evaporation ;* as can be seen from the vegetation growing close to the margins of alkaline lakes, with its roots immersed in the water.

Occasions when one may be forced to use saline waters.

The irrigator can determine for himself whether or not his water-supply is of doubtful character, by evaporating a tablespoonful, or more, in a clean silver spoon (avoiding boiling). If the dry residue should form simply a thin, powdery-looking film on the polished metal he may be assured that the water is all right. If, on the other hand, an obvious saline crust should remain, which will redissolve, in water, he should either have an analysis made, or use the water in such a manner as to remove the accumulated salts from time to time by washing them into the sub-drainage, if the nature of the soil permits. *A very abundant use of such waters is then preferable to a sparing one ;* but the user should *assure himself that it really penetrates,* for otherwise, especially in case much carbonate of soda is present, a dense hardpan may be formed that will allow the trees to perish from drought despite all the water running in the irrigation furrows. A pointed steel probe, three-sixteenths of an inch square, provided with a cross handle, like a hand auger, ought to be among the tools of every farmer for such tests of his sub-soil. No farmer in the arid region can afford to be ignorant of the nature of the substrata within which the bulk of the roots of his crops must vegetate.

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

RECLAIMABLE AND IRRECLAIMABLE ALKALI LANDS AS DISTINGUISHED BY THEIR NATURAL VEGETATION.

"While, as shown above, the adaptation or non-adaptation of particular alkali lands to certain cultures may be determined by sampling the soil and subjecting the leachings to chemical analysis, it is obviously desirable that some other means, if possible, available to the farmer himself should be found to determine the reclaimability and adaptation of such lands for general or special cultures.

"The natural plant growth seems to afford such means, both as regards the quality and quantity of the saline ingredients. The most superficial observation shows that certain plants indicate extremely strong alkali lands where they occupy the ground alone; others indicate pre-eminently the presence of common salt; the presence or absence of still others form definite or probable indications of reclaimability or non-reclaimability. Many such characteristic plants are well known to and readily recognised by the farmers of the alkali districts. 'Alkali weeds' are commonly talked about almost everywhere; but the meaning of this term — *i.e.*, the kind of plant designated thereby—varies materially from place to place according to climate as well as to the quantity of the soil. Yet if these characteristic plants could be definitely observed, described and named, while also ascertaining the amount and kind of alkali they indicate as existing in the land, lists could be formed for the several districts, which would indicate, in a manner intelligible to the farmer himself, the kind and degree of impregnation with which he would have to deal in the reclamation work, thus enabling him to go to work on the basis of his own judgment, without previous reference to this Station.

"The carrying out of such a plan involves, obviously, a very large amount of botanical as well as chemical work, which cannot be accomplished within a few seasons; and in view of the wide difference in the vegetation of the several alkali regions of the State the same work will have to be repeated to a certain extent in each of these regions. The object to be achieved is, however, of such high practical importance—an importance not remotely appreciated as yet by those not familiar with the enormous extent of otherwise desirable lands in this State that are more or less tainted with alkali—as to deserve the expenditure upon it of a large amount of work as promptly as possible.

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

"The extreme limitation of funds under which the Agricultural College, together with the University as a whole, has been suffering for some years past, has thus far restricted the scope of researches very closely both geographically and otherwise. It is hoped that in the future, a close comparison of the native vegetation with the chemical determination of the quantity and kind of alkali corresponding to certain plants, or groups of plants, naturally occurring on the land, may enable us to come to a sufficiently close estimate of the nature and capabilities of the latter from the native vegetation alone, or with the aid of test plants purposely grown. But before entering upon this complex problem, it has been thought best to determine, first of all, what lands may for present economic conditions be considered *irreclaimable* because their improvement would involve an expense out of proportion with present land values. So far as large areas are concerned, this may probably be considered to be the case when tile under drainage is required in order to wash out the salts; while of course smaller tracts, which interrupt the cultivation of fields, may frequently justify the laying of a few drain lines required to render them cultivable with the rest of the land.

"As stated in the report of this Station for 1895-97, the field work of this investigation, both botanical and in the collection of the corresponding soil samples, has been done by Mr. Joseph Burtt Davy, Assistant Botanist to the Station, who also supplies the notes accompanying the same; while the laboratory work for the determination of the amounts and kinds of salts present in the several cases has been carried out by Professor R. H. Loughridge.

"The plants hereinafter mentioned are then to be understood as indicating, *whenever they occupy the ground as an abundant and luxuriant growth* that such land is irreclaimable for ordinary crops, unless underdrained for the purpose of washing out surplus salts. The occurrence merely of scattered, more or less stunted individuals of these plants, while a sure indication of the presence of alkali salts does not necessarily show that the land is irreclaimable.

"The plants which may best serve as such indicators in California are the following:—

Californian indicators.

Tussock-grass (**Sporobolus airoides**, *Torr*).

Greasewood (**Sarcobatus vermiculatus**, *Torr*).

Dwarf Samphire (**Salicornia subterminalis**, *Parish*, and other species).

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

Bushy Samphire (**Allenrolfea occidentalis**, *O. Ktze.*, better known as **Halostachys occidentalis**, *S. Wats.*).

Salt-wort (**Suaeda torreyana**, *S. Wats.*, and **S. suffrutescens**, *S. Wats.*).

Alkali-heath (**Frankenia grandifolia** *var.* **campestris**, *A. Gray*).

Cressa (**Cressa cretica** *var.* **truxillensis**, *Choisy*).

Tussock-grass—so called because it grows in large clumps or tussocks (**Sporobolus airoides**, *Torr*).

Sporobolus airoides.

"The three sets of samples of Tussock-grass soil which have been analysed show that the total amount of all salts present is in no case less than 49,000 pounds per acre, to a depth of four feet, and that it sometimes reaches the extraordinarily high figure of 499,000 pounds. Of these amounts the neutral salts (glauber salt and common salt) are usually in the heaviest proportion (glauber salt, 19,600 to 323,000 pounds per acre; common salt, 3,500 to 172,800); the corrosive salsoda varying from 3,000 to 44,000 pounds. Tussock-grass apparently cannot persist in ground which is periodically flooded. This fact is of special importance because it is an acceptable forage for stock.

"Tussock-grass is a prevalent alkali-indicator in the hot arid portions of the interior, from the Upper San Joaquin Valley, the Mojave Desert, and southward; also through Southern Nevada and Utah as far east as Kansas and Nebraska. In the San Joaquin Valley we have not found it further north than the Tulare plains, although East of the Sierra it occurs near Reno. **Coville** observes that in the Death Valley region 'it is confined principally to altitudes below 1,000 metres' (3,280 feet). **Hillman**, however, reports it from near Reno, Nevada, at an altitude which cannot be much less than 4,500 feet.

"As we have received requests for precise information as to the localities in which this grass grows, from persons desiring to obtain seed for trial, the following list is given: Tulare plains a few miles south-east of Tulare; a few miles south of Bakersfield; in the Antelope Valley; along the road from Rosamond to Lancaster, and in alkali sinks about the Leonis Valley between Lancaster and Elizabeth Lake. It is reported by **Coville** from Death Valley, Pahrump

TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

Valley, Resting-Springs Valley, Owens River Valley, and other points in the desert region south-east of the Sierra Nevada. It is also recorded from near Barstow and other points in San Bernardino County; in dry soils near Los Angeles and from San Diego County.

"***Greasewood (the true Greasewood of the desert region east of the Sierra Nevada, and not either of the plants known under that name in the San Joaquin Valley and in Southern California,* Sarcobatus vermiculatus, *Torr.*).**

Sarcobatus vermiculatus.

"Through the courteous co-operation of Professor F. H. Hillman, Botanist to the Nevada Agricultural Experiment Station at Reno, we have obtained three series of samples of Greasewood soil from that vicinity. These samples show that where the Greasewood shrubs are thinly scattered and stunted in growth, the salt content per acre to the depth of three feet is about 2,400 pounds, of which over one half consists of the corrosive carbonates. Where a luxuriant growth occurs the total salts per acre vary from 38,000 to 58,500 pounds, with 18,700 pounds of salsoda and 920 to 3,680 pounds of common salt; the relative percentage of the injurious salsoda is thus invariably high. The common salt is low and the neutral glauber salt is variable. This plant, therefore, always indicates the presence of 'black alkali.'

"Greasewood is distinctly a plant of the Great Basin, only reaching California in the adjacent counties of Lassen, Alpine, Mono and Northern Inyo. It is very abundant on the lower levels of Honey Lake Valley.

"***Dwarf Samphire* (Salicornia subterminalis, *Parish, and other species of the interior*).**

Salicornia subterminalis.

"The two or three species of Dwarf Samphire which grow in the interior valleys of the State are nowhere very abundant in those portions of the alkali region which we have thus far investigated. Wherever the species do occur, however, they are confined to such very strongly saline soils that they may be considered valuable indicative plants. We have as yet only one full set of samples of Dwarf Samphire soil. This shows the total salt content to amount to 441,880 pounds per acre in a depth of four feet. The neutral glauber salt amounts to 314,000 pounds, almost as much as in Tussock-grass soil; common salt up to 125,640 pounds, while the

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TO JUDGE RECLAIMABLE LANDS BY THEIR VEGETATION.

salsoda varies from 2,200 to 12,000. We may consider this plant as indicative of almost the highest percentage of common salt, glauber salt and total salts. Like the preceding species, it indicates 'white' salts in excessive amounts, and a sub-soil too wet for the Australian salt-bush. **Salicornia subterminalis** occurs in San Diego, Riverside, Los Angeles, and Kern Counties. **S. herbacea,** *L.*, is reported from Riverside County, and from the margin of Tehachapi Lake, Kern County. **S. mucronata,** *Bigelow*, occurs in San Diego County; and a fourth species is found in the Antelope Valley, Los Angeles County; near Bakersfield, Kern County; and at Byron Springs, Contra Costa County. These inland species all differ materially in habit and botanical characters from the one common in submerged salt marshes along the seashore, but all alike indicate strongly saline soils.

"***Bushy Samphire*** (**Allenrolfea occidentalis,** *O. Ktze.*, better known as **Haloschys occidentalis,** *S. Wats.*).

Halostachys occidentalis.

"This plant is locally called greasewood, but as this name is much more commonly used for **Sarcobatus vermiculatus,** it seems best to call it 'bushy samphire,' as it closely resembles the true samphire (**Salicornia**).

"Bushy samphire usually grows in low sinks, in soil which in winter is excessively wet and in summer becomes a 'dry bog.' Whenever the plant grows luxuriantly the salt content is invariably high, the total salts varying from 327,000 per acre, to a depth of three feet to 494,520 pounds in four feet. The salts consist mainly of glauber and common salts (a maximum of about 275,000 pounds of each); salsoda varies from 2,360 to 4,800 pounds per acre. The percentage of common salt and total salts is higher than for any other plant investigated, and the glauber salt is almost proportionate. The areas over which this plant grows must, therefore, be considered as among the most hopeless of alkali lands, for although its salts are 'white,' submergence during winter precludes the growth of Australian salt-bush.

"Bushy Samphire is a common plant in alkali soils in the Upper San Joaquin Valley, around Bakersfield and Delaro; a few stunted bushes occur near the margin of Tulare Lake, west of Tulare, but at that point it appears to be dying out. It also occurs on the east slope of Livermore Pass, and in an alkali sink in a pocket of the hills at

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Byron Springs, Contra Costa County. In the Death Valley region the plant appears to be very abundant, occupying an area considerably more southern than what appears to be the southerly limit of Greasewood (Sarcobatus).

"*Salt-worts* (Suaeda torreyana, *S. Wats.*, S. suffrutescens, *S. Wats., and perhaps one other species*).

Suaeda spp.

"Samples of Salt-wort soil from Bakersfield, Kern County, and Byron Springs, Contra Costa County, taken to a depth of one foot and three feet, respectively, show that this plant grows luxuriantly in a soil containing 130,000 pounds of salts per acre in the first foot, and with 10,480 pounds of the noxious salsoda, and 39,760 pounds of common salt in three feet; while only a sparse growth is found on soils containing only 3,700 pounds of salts in three feet. It thus appears to indicate a lower percentage of salsoda than does Greasewood, but a higher percentage than Bushy Samphire. Further investigation is necessary to determine the exact relation of the different salts to the growth of the plant, and as to whether carbonates always occur in large quantity; but enough data have been gathered to show that a luxuriant growth of Salt-wort indicates a soil practically irreclaimable except at the expense of leaching.

"Suaeda torreyana occurs in abundance in certain alkali soils near Bakersfield, Kern County; in a large alkali sink near Colusa Junction, Colusa County; in Honey Lake Valley, Lassen County; Antelope Valley, Kern County; and in the vicinity of San Bernardino. Coville reports having collected it at Lone Pine, Inyo County. The closely related species, S. suffrutescens, only to be distinguished by an expert botanist, occurs in abundance in the alkali soils of the Mojave Desert, Death Valley, the Tulare plains, and near Bakersfield. The different species of Salt-wort grow in similar habitats, and it is probable that the condition of the soil is approximately the same for each species. It thus indicates land that, while not capable of bearing ordinary crops, will probably allow the Australian salt-bush to succeed, at least with the aid of some gypsum.

"*Alkali-Heath* (Frankenia grandifolia *var.* campestris, *A. Gray*).

Frankenia grandifolia.

"Alkali-heath is perhaps the most widely distributed of any of our California alkali plants. Its perennial deep-rooting habit of growth,

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and flexible, somewhat wiry rootstock, which enables it to persist even in cultivated ground, render it a valuable plant as an alkali indicator. The salt content where Alkali-heath grows luxuriantly is invariably high, ranging from 64,000 to 282,000 pounds per acre; salsoda varies from 680 to 19,590 pounds; common salt ranges from 5,000 to 10,000 pounds. Such soils would not be benefited by the application of gypsum, as the salts are already largely in the neutral state. Of useful plants only Salt-bushes and Tussock-grass are likely to flourish in such lands.

"While Alkali-heath is thus one of the most alkali-tolerant plants, it is at the same time capable of growth with a minimum of salts (total salts 3,700 pounds, salsoda 680 pounds). Where only a sparse growth of this plant occurs, therefore, the land should not be condemned until a chemical examination of the soil has been made.

"Alkali-heath is found on soils of very varying physical texture and degrees of moisture; while on soils of uniform texture and moisture, but differing in chemical composition, it varies with the varying salt-content.

"It has been found that Australian Salt-bush **(Atriplex semibaccata)** can be successfully grown on the Colusa County 'goose lands,' on soil producing a medium crop of Alkali-heath; it remains to be shown whether it will do equally well on soils producing a dense and luxuriant growth of the same.

"Alkali-heath is so widely distributed throughout the interior valleys of California that it would be superfluous to give a list of the localities in which it occurs. A closely related form is found in salt marshes along the coast, differing from that of the interior principally in its much broader leaves.

Cressa cretica.

Cressa (**Cressa cretica** *var.* **truxillensis**, *Choisy*).

"Cressa soils show a low percentage of the noxious salsoda, but comparatively heavy total salts (161,000 to 282,000 pounds per acre). Common salt varies from 5,760 to 20,840 pounds per acre in four feet. The maximum is lower than in the case of Alkali-heath, but Cressa seems to be much more closely restricted to strong alkali than does the former species. Cressa appears to be as widely distributed through the interior valleys of the State as Alkali-heath. It is a cosmopolitan plant, occurring as its name indicates, on the Ionian Isles, as well as in North Africa, Syria, and in other arid countries of the world.

of Alkali Lands. (*E. W. Hilgard.*) REH.

TOLERANCE OF SALINITY, IN CHARACTERISTIC CALIORNIAN PLANTS.

" *RELATIVE TOLERANCE OF THE DIFFERENT SPECIES.*

" In order to determine the relative nature of the soils characterised by each of the above-named plants, Mr. Davy has prepared the following table, in which the column marked *optimum* shows, as nearly as possible with our present knowledge of the subject, the condition of the soil where each species grows in about equal luxuriance. For Salt-wort and Dwarf Samphires we have not yet been able to obtain as thoroughly characteristic soil samples as could be desired, but we hope to be able to do so during the coming season.

" It must be understood that the *optimum* indicates the condition under which the plant has been found at its greatest luxuriance—where it is evidently 'at home'—; whereas the maximum and minimum have sometimes been obtained where the plants were more or less stunted in growth and sparingly scattered over the ground.

" ***Table showing Maximum, Optimum, and Minimum of Salts tolerated by each of the several Alkali Plants.***

	Pounds per Acre		
	Optimum.	Maximum.	Minimum.
Total Salts.			
Bushy Samphire . . .	494,520	494,520	135,060
Dwarf Samphires . . .	441,880	441,880	441,880
Alkali-heath	{ 281,960 64,300 }	499,040	3,720
Cressa	281,960	281,960	161,160
Salt-worts	130,000	153,020	3,720
Greasewood	58,560	58,560	2,400
Tussock-grass . . .	49,000	499,040	49,000
Carbonates (Salsoda).			
Tussock-grass . . .	23,000	44,460	3,040
Alkali-heath	{ * 19,590 680 }	19,590	680
Greasewood	18,720	18,720	1,280
Dwarf Samphires . . .	12,120	12,120	2,200
Salt-worts	10,480	12,120	1,120
Cressa	5,440	5,440	680
Bushy Samphire . . .	4,800	4,800	1,500

* This plant grows with equal luxuriance in soils containing only 680 pounds of carbonates.

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" *Table showing Maximum, Optimum, and Minimum of Salts, etc.*—contd.

	Pounds per Acre		
	Optimum.	Maximum.	Minimum.
Chlorides (Common Salt).			
Bushy Samphire . .	212,080	275,160	56,800
Dwarf Samphires . . .	125,640	125,640	125,640
Salt-worts	39,760	52,900	1,040
Cressa	20,840	20,840	5,760
Alkali-heath	{ 10,180 5,760 }	212,080	1,040
Tussock-grass . . .	6,200	172,800	3,530
Greasewood	3,680	3,680	160
Sulphates (Glauber Salt)			
Dwarf Samphires . . .	314,040	314,040	314,040
Bushy Samphire . . .	277,640	277,640	50,080
Cressa	275,520	275,520	134,880
Alkali-heath	{ 275,520 34,530 }	323,200	1,560
Salt-worts	44,160	104,040	1,560
Greasewood	36,160	36,160	960
Tussock-grass . . .	19,640	323,200	19,640

" In these tables the sequence of the different plants has been arranged so that in each case the species having the highest optimum comes at the head of the list. Arranged in this way the tables show that where these plants grow in luxuriance they may be considered indicative of the following conditions :—

" ***Total Salt Indicators.***—The Samphires, Alkali-heath and Cressa are all indicative of excessive total salts. Salt-wort, Greasewood, and Tussock-grass indicate much lower salt-content; indeed, the maximum of the two latter plants (Greasewood and Tussock-grass) indicate much lower total salt-content; indeed the maximum of the two latter plants (Greasewood and Tussock-grass) is so low that the application of gypsum (land-plaster) would *in some cases* (*e.g.* the Tussock-grass lands near Bakersfield) render the soil adapted to the cultivation of Modiola and Australian Salt-bush.

" ***Salsoda Indicator.***—It is noticeable that the relative position of the different species in the columns of optimum and maximum is more uniform in the salsoda table than in any other; and whether

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we arrange the sequence of the plants according to the optimum or to the maximum, the same relative position is maintained. This is in complete accord with what our knowledge of the effect of salsoda on vegetable life would lead us to expect; being by far the most injurious of the alkali salts, the range of tolerance is much smaller, and the limits are much more clearly defined than in the case of the other salts.

"Luxuriant growths of Tussock-grass and Greasewood are invariably indicative of high percentages of carbonates, but in such cases the total salt percentage is sometimes so low that the application of gypsum (land-plaster) would render the land fit for the cultivation of Modiola or even Australian Salt-bush, as noted above. It must be borne in mind, however, that where Tussock-grass grows but sparsely, the total salt-content may reach 499,000 pounds, an amount rendering the land utterly worthless for agricultural purposes unless the surplus salts can be removed.

"Alkali-heath cannot be taken as an accurate guage of the salsoda content as it grows with equal luxuriance on soils containing, respectively, 680 and 19,590 pounds to the acre, of this salt.

"The Samphires and Salt-worts are relatively low down in the carbonate table, and may be taken to indicate a comparatively low percentage of 'black alkali.'

"***Neutral-Salt Indicators.***—The Samphires and Salt-worts head the neutral salt tables, and are reliable indicators of excessively high percentages both of glauber salt and of common salt. Salt-wort comes next to Samphire in the common-salt table, but is not quite such a good guide to the glauber salt.

"Luxuriant growths of Alkali-heath, Greasewood, and Tussock-grass indicate low percentages of the neutral salts, but these plants will sometimes tolerate (in a sparse state of growth) very high percentages."

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INDIAN ALKALI SOILS, THEIR LITERATURE AND USEFUL PLANTS.

REH.

References.—*Manual Geology of India* I., 413—15; *Ball, Economic Geology*, III., 696; *Memoirs Geological Survey of India*, XII., 253; *Dr. Center in Records Geological Survey of India*, XIII., 253; XXIV., 68—9; *Manual Geology of India*, 447—9; *Report by Mr. W. J. Ward upon the Soils and Waters from the Reh lands on the Western Jumna Canal* (1887); *Ind. Agriculturist*, Sept., Oct., 1892; *Ind., Engineer*, Nov., 1892; *Report of Dept., Land Records, and Agriculture, N. W. P. and Oudh*, 1893, 4—6; 1894, 5—7 and 25; 1895, 5—7; 1896, 5—8; 1897, 21—24; 1898, 17—21; 1899, 13—15; *Final Report of Dr. J. Walter Leather, F.I.C., F.C.S.*, 36, 37; *Ind. Agriculturist*, June 1898, p. 164; *The Statesman*, Oct. 19, 1900; *Report of Dept. Land Records and Agriculture, Bengal*, 1900, p. 20; *The Agricultural Ledger*, 1893, Nos. 12 and 13; 1896, Nos. 1 and 33; 1897, Nos. 7 and 13.

SAND-BINDING PLANTS.

References.—*Baron F. von Mueller, Select Extra-tropical Plants*, 465; *Maiden, Useful Native Plants of Australia*, 85, 349, 637, 642, 643, 644; *Man. Mad. Adm.*, II., 27; *R. & A. Dept. Correspondence regarding Sand-binding Plants*, 1882-83; *Proc. Agri.-Horticultural Soc., Madras*, Feb. 1884; *Agri.-Hort. Soc. Ind. Journal* (*Old Series*), IX., 174; *The Tropical Agriculturist*, 1883-84, p. 11; *Balfour, Cyclop. Ind.*, III., 818; *Year-Book of U. S. Dept. of Agri.*, 1894, p. 580; 1898, pp. 405—20, also pp. 535—50; *The Agricultural Ledger*, 1893, Nos. 12 and 13; 1896, Nos. 1, 21, and 33; 1897, Nos. 7, 12 and 13.

The appended list contains the more important and common sand-binding plants which occur in India.

Acacia arabica, *Willd.*
A. eburnea, *Willd.*
A. Jacquemontii, *Benth.*
Agave americana, *Linn.*
Agrostis alba, *Linn.*
Alhagi maurorum, *Desv.*
Andropogon foveolatus, *Del.*
A. laniger, *Desf.*
Aristida depressa, *Retz.*

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Aristida setacea, *Retz.*
Atriplex nummularia, *Lindl.*
Calotropis gigantea, *R. Br.*
C. procera, *R. Br.*
Canavalia obtusifolia, *DC.*
Capparis aphylla, *Roth.*
C. spinosa, *Linn.*
Casuarina equisetifolia, *Forst.*
Cenchrus catharticus, *Del.*
C. montana, *Nees.*
Eleusine ægyptiaca, *Pers.*
E. flagellifera, *Nees.*
E. scindica, *Duthie.*
Elionurus hirsutus, *Munro.*
Indigofera *sp.*
Hydrophylax maritima, *Linn.*
Ipomœa biloba, *Forsk.*
Jatropha Curcas, *Linn.*
J. glandulifera, *Roxb.*
Launea pinatifida, *Cass.*
Melanocenchris royleana, *Nees.*
Opuntia Dillenii, *How.*
Pandanus odoratissimus, *Willd.*
Pennisetum cenchroides, *Rich.*
Perotia latifolia, *Ait.*
Pupalia orbiculata, *Wight.*
Saccharum ciliare, *Anders.*
Salvadora oleoides, *Dcne.*
S. persica, *Linn.*
Spinifex squarrosus, *Linn.*
Sporobolus orientalis, *Kunth.*
Tamarix gallica, *Linn.*
Zizyphus nummularia, *W. & A.*

G. I. C. P. O.—No. 872 R. & A.—15-6-1901—2,230—C. M. W.

(Vegetable Product Series, No. 65.)
(Dyes and Tans.)

THE AGRICULTURAL LEDGER.

1901—No. 6.

GERANIUM NEPALENSE, *Sweet.*

G. WALLICHIANUM, *D. Don.*

[*Dictionary of Economic Products, Vol. III.,* 177-83.]

THE PROPERTIES OF INDIAN GERANIUM ROOT.

By MR. D. HOOPER, F.I.C., F.C.S.

PROPERTIES OF THEIR ALLIES.

Species of Geranium or Cranesbill growing in Europe and Asia have been known from remote times to possess medicinal virtues. **Dioscorides** mentions a plant called geranion as employed for its astringent properties, and **Pliny** alludes to two species which were known in his time.

Use of G. Robertianum.

The root of the Herb Robert (**Geranium Robertianum,** *Linn.*,) was formerly much used in European Medicine for fever, consumption and jaundice, and externally as a resolvent to swollen breasts and tumours. The herb is now almost entirely neglected.

Use of G. maculatum.

In many parts of the United States the root of **G. maculatum** is esteemed as one of the best indigenous astringents, and is included in the National Dispensatory. Diarrhœa, chronic dysentery, cholera infantum and hæmorrhage are the diseases for which it is specially recommended. It is said to be free from the unpleasant taste and odour of the common European species of cranesbill.

Composition of American root.

Dr. Edward Staples in 1829 found the American drug to contain tannic and gallic acids and a red colouring matter. This result was confirmed in 1863 as the result of an investigation by **Mr. Tilden. Messrs. Trimble** and **Peacock** in 1891 again examined several samples of the fresh and dried rhizome and found gallotannic acid to occur to the extent of 3·2 to 6·7 per cent. in the fresh, and 9·7 to 27·8 per cent. in the absolutely dry drug. This

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principle is present in largest amount in April just before the plant blooms, and rapidly decreases until it reaches a minimum in October; thus pointing to the possibility of its being a storage material to assist the plant in blooming and perfecting its seed.

Monsonia ovata used at the Cape.

The astringency of other plants of this natural order has been observed in other parts of the globe. For instance, the root of the wild Pelargonium (**Monsonia ovata**, *Cav.*) of South Africa has attracted attention for many years, and was probably brought to the notice of the early settlers by the natives. This plant is called *Neeta* or *Geita* by the Kaffirs, and being very astringent, it has been used with great success in dysentery.

The Kaffirs simply chew the root, which somewhat resembles that of the gentian, but a more palatable mixture is made by boiling four ounces of the root for twenty minutes in a pint of milk, and one or two tablespoonfuls are given every two hours. Mr. J. Maberly, M.R.C.S., published a long record of cases in which a tincture of **Monsonia** was employed successfully in dysentery (*Lancet*, February 6, 1897, page 368). The plant is collected in January and February from the Vaal River district. Mr. J. Medley Wood, Curator of the Botanic Gardens, Durban, states that the root of **Monsonia biflora**, *DC.*, is also used for the same purpose in Natal. A figure of the plant which is called the Cape remedy for dysentery, appeared in the *Cape Agricultural Journal* for 1897, (*vol. X., p. 59*). In the accompanying article written by Mr. P. Macowan, the Government Botanist, a member of the same natural family, **Pelargonium reniforme**, *Curt.*, is also said to have a local reputation for dysentery.

Pelargonium reniforme.

Dr. Sharp's examination of Monsonia root.

Dr. J. Gordon Sharp, of Edinburgh, has recently examined an authentic sample of **Monsonia ovata** root, and he found the chief constituent to be gallotannic acid. The non-toxic nature of the root, and the absence of any appreciable quantity of glucoside or alkaloid, influenced the author in concluding that the drug was an unimportant one as a medical agent.

Differences in results may be due to age of root.

The conflicting opinions with regard to the useful administration of these roots is no doubt caused by the different ages at which they are collected, and the seasons of the year when they are richer or poorer in the yield of their active principle.

There are four species of **Geranium** described in the *Dictionary of Economic Products of India*, *viz.*, **G. nepalense**, *Sweet*,

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G. ocellatum, *Camb.*, **G. Robertianum**, *Linn.*, and **G. Wallichianum**, *D. Don.* The first and the last named species, on account of their greater importance and wide distribution, are accordingly here referred to in some detail. INDIAN SPECIES OF GERANIUM.

Geranium nepalense, *Sweet; Fl. Br. Ind.*, *I.*, *430; Wight, Ill. I. 153, t. 59; Ind. Kew. II.*, *1020.* G. nepalense.

Syn.—GERANIUM RADICANS, *DC.*; G, PALLIDUM and G. PATENS, *Royle*; G. AFFINE, *W. & A.*; G. ARNOTTIANUM, *Steud.*

Vern.—*Bhanda*, HIND; *Bhánda*, Root in bazars-*rowil, chand*, PB.

References.—*W. & A. Prod.*, *133; Stewart, Pb. Pl.*, *36; Botany of tour in Hazara in Agri. Hort. Soc. of India Journ.* (*old series*), *XIV.*, *16; Pharmacog. Indica, I.*, *248; Baden Powell. Pb. Pr.*, *334; Atkinson, Him. Dist.*, *307.*

Habitat.—A herbaceous prostrate plant, common throughout the temperate Himalaya at altitudes of from 5,000 to 9,000 feet; found also in the Khasia Hills, the mountains of Southern India, and Ceylon. Distributed to Yunnan.

Dye.—Dr. J. L. Stewart states that the root forms an article of trade, being brought from the hills to the plains of the Panjab, and sold as a dye. Mr. W. R. Lawrence in his "Valley of Kashmir" speaks of the roots of **G. nepalense** being a common substitute for **Rubia cordifolia** and of their both being known under the name of *Mazait*, or *Majit*, probably derived from the more frequently used vernacular *Manjit*. This was said to be used for dyeing wool for the carpet manufacturers. As a dye-stuff. Confused with manjit.

In 1896 steps were taken by the Reporter on Economic Products to obtain a consignment of the root collected and sold in Kashmir under the name of Bhanda (**Geranium**). A parcel of the dye material was received from the Governor of Kashmir in April, and this was identified as the root of **Rubia cordifolia** (Reg. No. 7432). Subsequently a further packet of roots was received from the Conservator of Forests, Kashmir, and these had the characteristics of the genuine article, and were registered as **Geranium nepalense** (No. 10098). In December 1899, Mr. J. F. Duthie, F.L.S., Director of the Botanical Survey of Northern India, forwarded from Saharanpur some authentic specimens of this root which had been collected a few months previously in the rainy season. These were recorded under registration number 14648. Mr. Duthie's specimens were much smaller roots than those from Kashmir, and,

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as will be seen from their analysis, are of a different composition. The larger roots from Kashmir were cylindrical and shrivelled, about 3 to 4 inches in length, dark brown in colour, with reddish-brown, close fracture. A section of the root showed a ring of yellowish detached wood-wedges near the cambial line, half way between the circumference and centre. The root had an astringent taste, and a faint odour of tan. The roots from Saharanpur were only one to two inches in length, reddish-brown in colour, and beset with numerous fine rootlets.

Description of root of G. nepalense.

They afforded the following composition on analysis :—

Analyses of roots of G. nepalense.

	Kashmir.	Saharanpur.
Tannin	43·58	10·82
Geranium-red	7·85	3·34
Fat	·73	·54
Sugar, gum, etc.	13·69	9·40
Starch, etc.	9·90	32·28
Crude fibre	9·80	19·42
Ash	4·35	12·20
Moisture	10·10	12·00
	100·00	100·00

It is stated in *Pharmacographia Indica* (page 249) that this root affords abundance of red colouring matter and is used for colouring oil like alkanet (**Onosma echioides**); but the above roots on being tested were found to possess no such property.

G. Wallichianum.

Geranium Wallichianum, *D. Don; Fl. Br. Ind., 1,430; Wight, Ic., t. 324; Ind. Kew. II., 1022.*

Vern.—*Liljahri,* N.-W.P.; *Kao-ashud,* KASH.; *Roots-Mam-i-ran,* AFG.

References.—*Aitchison, Fl. Kuram Valley, 25, 39, Pharmacog. Indica 1,248 Atkinson, Him. Dist., 307. Kew Bulletin 1896, p. 29.*

Habitat.—A herb with large bluish flowers, native of temperate Himalaya from Nepal to Murree, at altitudes of 7,000 to 11,000 feet. Aitchison also describes it as met with in the Kuram Valley, "amongst bushes, grass and boulders, where there is moisture, from 8,000 to 10,000 feet."

As a dye-stuff.

Dye.—In 1895 Brigade Surgeon (retired) J. E. T. Aitchison, C.I.E., F.R.S., sent a considerable quantity of the dried roots to Kew. They were stated to be largely used as a dye stuff in Kashmir. The roots were submitted to J. J. Hummel, Esq., Professor of Dyeing in the Yorkshire College, Leeds, who furnished the following report to the Director of the Royal Botanic Gardens, Kew, in December of that year.

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"Enclosed I now send you samples of calico printed with aluminium and iron mordants and dyed with roots of **Geranium Wallichianum**, from Kashmir. The dark grey given by the iron mordants, and the pale soiled yellowish tints on the aluminium mordants show that these roots contain essentially tannin matter unaccompanied by any mordant dyeing colouring matter for which cotton has a natural attraction, but which must be regarded as of no commercial importance; indeed, regarding the roots as a useful tannin matter the presence of this red colouring matter is somewhat objectionable.

"In comparison with Sumach and Myrobalans, patterns dyed with which are enclosed, it would appear that **G. Wallichianum** roots are about equal to the latter as regards amount of tannin matter present, and I have no doubt they could be usefully employed by the dyer for certain purposes either in the form of powder or as an extract, in the same manner as other tannin matters are employed."

As a tan.

Tan.—Professor H. R. Procter, of the Leather Industries Laboratory, Yorkshire College, Leeds, submitted the following results of his analysis of the roots of this plant to the Director of Kew Gardens in December, 1895:—

"The sample of root contains 43·5 per cent. of matter soluble in water, and, determined by the gravimetric hide powder method, gives—

Tanning matter absorbed by hide . . .	25·7
Soluble non-tanning matter	17·8
Vegetable fibre and insoluble	43·0
Moisture	13·5
	100·0

The colour of the extract is somewhat dark and reddish, but that of leather tanned with it is much brighter than might have been expected from the appearance of the liquor, and there certainly seems no reason why, if the material can be obtained in sufficient quantities, it should not form a valuable addition to our tanning materials. The leather produced is somewhat darker but not very dissimilar to that obtained by the use of canaigre root (**Rumex hymenosepalum**)." *Kew Bulletin*, January 1896, page 30.

A sample of roots of **G. Wallichianum** was collected by the author in Mussoorie in the month of September 1900. These had

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a similar appearance to those of the samples of **G. nepalense** from Kashmir. The roots were long and shrivelled and the section showed the peculiar ring of wedge-shaped bundles of wood. The chemical analysis revealed the following composition:—

Analysis of roots from Mussoorie.

Tannin	32·00
Geranium red	7·49
Fat	·54
Sugar, gum, etc	14·15
Starch, etc.	14·56
Fibre	12·41
Ash	4·70
Water	14·15
	100·00

This root was tested, as in the former species, to ascertain if it contained a red colouring matter soluble in fixed oils, but no colour was communicated to the oil after contact for one month. There is sufficient evidence, therefore, in concluding that the roots are distinctly a tan and not a dyeing agent.

Medicine.

Medicine.—Dr. Aitchison writes: "At Alikhel a native brought me the stems of the plant which he said was a rare and valuable medicine"; and in another passage: "The rhizomes of this plant were brought to me (said to be from some hills 30 miles off) as the *mami-ran*, a good medicine for sore eyes. This is doubtless a local substitute for the true *mami-ran*, *i.e.*, the roots of **Coptis Teeta**, *Wall.*" Mr. Duthie states that in the village of Jumnotri it is employed as a cure for toothache.

Conclusion.

Enquiries having recently been made respecting the properties of the wild geranium roots of this country, it was thought that the publication of the above facts would be of interest. It has been observed that the roots of two of the commoner species yield from 10·82 to 43·58 per cent. of tannic acid similar to that of oak-galls, but the amount of this principle varies with the age of the plant and the season of collection. There is no doubt that we possess in these roots a simple and useful astringent which might with advantage be employed more widely in medicine or the arts than it has been hitherto.

G. 177-83.

G. I. C. P. O.—No. 1420 R. & A.—25-6-1901.—2,230.—B. N. D.

THE AGRICULTURAL LEDGER.

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A PLAGUE IN THE BETEL-NUT PALMS,

AND

THE DESTRUCTION OF THE TISSUES BY WHAT APPEARS TO BE A FORM OF TYLOSES.

ARECA CATECHU, *Linn.; Dict. Econ. Prod., Vol. I.*, A. 1294-1328.

REPORT

ON A

TOUR IN THE KHULNA, BACKERGANJ AND NOAKHALI DISTRICTS OF EASTERN BENGAL.

By GEORGE WATT, ESQ., M.B., C.M., C.I.E., *Reporter on Economic Products to the Government of India.*

HISTORY OF THE ENQUIRY.

BETEL-NUT PALM DISEASE.

My attention was first directed to the disease that had appeared in the Betel-nut palms, through a letter received from the Director of the Department of Land Records and Agriculture, Bengal. This was dated 20th March 1896 and stated that the specimen of diseased palm forwarded for my inspection and report had been brought to Calcutta by a resident in the district of Backerganj. The Director added, for my information, that the disease had shown itself in the form of an epidemic, the injury being reported as very serious. I was also informed that an Assistant Director (Mr. N. G. Mukharji), had been deputed to investigate locally into the cause of the disease and to suggest remedial measures. The Director added, however, that he wished my opinion "as to what the disease is, what are the probable causes of it, and what remedies may be applied to arrest its progress."

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2. I examined the specimen as carefully as possible and may as well record here my observations and action, since these have a bearing on my subsequent investigations. The specimen was the top 4 or 5 feet of a betel-nut palm (perhaps 20 years old, the stem being about four inches in diameter), with its usual crown of leaves. Externally the plant looked fairly healthy. The upper portion of the stem was green, and though one or two of the leaves were broken and withered they were not more so than might have arisen from the plant having been cut down and handled somewhat roughly (and unavoidably so) during a journey by boat and rail of some two or three days' duration. The lower end of the stem was, however, decomposed and maggot infested. A number of small black beetles also escaped from the stump. This led me to slit the stem up lengthwise, when it was seen the maggots were confined to a few inches of the lower extremity that had very possibly got decomposed since the tree had been felled. The white starch-like granular structure of the stem with its fibrovascular bands looked otherwise quite healthy. There were no stains, no unhealthy patches, such as might have been expected through the presence of some parasite.

Maggot Infested Stem.

3. ***External Manifestations of the Presence of Fungi.***—I then examined the epidermis of the green portion of the stem, of the leaf sheaths and of the leaves themselves to see if there were any indications of a parasitic fungus. In this I failed absolutely. The withered leaves were, however, attacked by a black mould, the mycelia of which had decomposed the cellular tissue and reduced the leaf-stalks to a mass of fibres in a rotten condition. I satisfied myself that this was a purely saprophytic action and could be in no way connected with the disease of the palms.

No Fungus Visible.

4. ***Rotten and Maggot Infested Buds.***—I then slit the leaf sheaths open and was much surprised to find in every case the contained buds in an advanced state of decomposition and maggot infested. They also emitted a most offensive smell. But I was not a little surprised to find that the maggots were apparently identical with those seen in the rotten stump of the stem. I examined the stump again with the greatest care in order to see if, by any chance, the tree could have been felled purposely through a diseased portion. As this seemed unlikely but rather that the stem had decomposed and been maggot infested since having been cut down, the invasion of the buds and the stump with what appeared the same species of

Maggot Infested Buds

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insect led me to infer that in both cases very possibly the maggots had appeared subsequent to the death of the structures concerned, and were not the cause of death.

Maggot Infested Buds.

5. I further noted that the base of the terminal bud near its union with the stem had also begun to decompose and to become maggot infested, while the two leaves partially expanded from it still remained quite green and stood erect. Major Alcock, I.M.S. (Superintendent of the Indian Museum), chanced to call on me while I was engaged with this examination; I accordingly asked him to be good enough to look at the maggots and to favour me with his opinion on them. He took away certain portions that were infested, and undertook to ascertain what the insects were by breeding them into their mature state. In his reply, dated 18th April, Major Alcock reported that "three different kinds of Dipterous insects, names unknown, have been bred from the piece of the stem of betel-nut palm." Although this is anticipating the sequence of events somewhat, I may say that I have been led subsequently to infer from the multiplicity of the insects found in the decomposing stems and buds that these could not be the cause of a specific disease to the trees, but rather a consequence of that disease.

Nucleated Cells within the Vessels. *Conf. with para. 74.*

6. ***Vessels of Diseased Tissue filled with Nucleated Cells.***—As I had failed to detect by means of a lens and low power microscope any external fungus, I took the liberty to send a few of the decomposed buds and their embracing leaf sheaths to Colonel D. D. Cunningham, C.I.E., I.M.S., for examination.

There was unfortunately at that time no microscope in the office of Reporter on Economic Products, and my private one having been injured during a recent tour of exploration in Assam, I was unable to examine the tissue of the diseased parts. Dr. Cunningham very obligingly complied with my request and his letter of the 31st March confirmed the general impressions I had formed. He then wrote: "I have examined the specimens of Areca blight, and must confess they are a puzzle to me. There is not a trace of any ordinary fungal disease about them, but at the same time the vessels and ducts present very curious appearances being in many cases absolutely plugged with masses of relatively large very delicate nucleated cells. I am unfortunately too ignorant of the histology of palms to know how far this may be taken as a pathological phenomenon, but I have asked Dr. King to let me have healthy specimens for

Conf. with Plate II., figs 4 and 5.

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comparison. In the meantime and on the supposition that the condition is a pathological one, the only thing which the appearances possibly suggest is that the disease is of a **Mycetozoa** origin!"

Position of the Buds.

7. ***Further Particulars Regarding the Buds.***—By my letter No. 932 of the 27th March, I informed the Director of the Department of Land Records and Agriculture of the above action, I called for further material, and asked that attention might be directed to discover whether the disease invariably proceeded from the buds contained within the leaf sheaths. I may explain that the leaf sheaths are often 18 inches to 2 feet long, and that they unite around the stem, each forming a closely adhering tube, within which, and right at the bottom, the flowering buds are found. As these buds enlarge the sheaths are split open, a bulging being formed for some days before the sheath ruptures. I would explain also that in the specimen supplied to me on the 20th March, the buds were large triangular bodies from 2 to 3 inches long and nearly as broad and placed right at the base of the sheaths. But in every case, notwithstanding their being so carefully protected they had turned brown, and what was remarkable those in the higher and more tightly fitting leaf sheaths were, if anything, in a more advanced state of decay than the lower and outer and partly expanded buds. In many cases also the decomposition was seen to have extended to the leaf sheaths themselves, large patches of the inner surfaces of which had changed to a more rusty brown, it is true, than the putrid buds, but they were clearly in an unhealthy state. There were, however, on these rufous patches no manifestations of the external fructification of a parasitic fungus. (*Conf. with para. 36.*)

8. ***Mr. N. G. Mukharji's Report.***—Along with the Director's letter No. 625 A., dated the 27th April, I obtained a copy of Mr. Mukharji's report of his investigations in the districts badly affected by the disease. This, while giving much interesting information as to the extent of the malady, its distribution, date of appearance and particulars of a former, and presumedly similar, outbreak 20 years ago, proceeded to attribute the disease to a fungus that he identified as very possibly a species of **Pythium**. In support of this view of the case he forwarded certain microscopic slides showing various stages of that fungus. These I at once examined with a low power microscope, but, as I failed absolutely to find anything to support Mr. Mukharji's views, I sent them to Colonel. D. D. Cunningham, C.I.E.,

Reported to be a species of Pythium.

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I.M.S., for his opinion. He was good enough to invite me to come to his laboratory to see Mr. Mukharji's slides, and at the same time to examine other specimens which he had himself prepared from the material sent to him. We examined the slides with the greatest care, but as Dr. Cunningham had previously written me, there was not a suggestion of a **Pythium** or **Peronospora** to be found. What deceived Mr. Mukharji, apparently, was a somewhat curious **Alga (Cephaleuros mycoidea)** which is frequently prevalent on the leaves. It is, therefore, hardly necessary to enlarge upon the issues raised by Mr. Mukharji's report.

Numerous Saprophytic Fungi.

No sooner have the tissues of the leaf, bud, or stem, been killed than they become a perfect botanic garden of saprophytic fungi and harbour also countless forms of insect life. The temptation is, therefore, very great to divert attention from cause to effect and to wander through and get lost in the unexplored field of fungal forms to be found on the decomposing structures.

BURNING AND FUNGICIDES.

Disease of Fungoid Origin.

9. I take the opportunity of mentioning here that I was fortunate in obtaining on loan, from the Mathematical Instrument Department, a microscope of sufficient power to enable me to examine the second consignment of samples sent to this office. I thought it as well, however, to advance no very definite opinions, and to leave Mr. Mukharji to be possibly correct until I had had the opportunity of more fully establishing my own views. Accordingly my reply No. 1205—222, dated the 29th April, stated that I had obtained indications that pointed in the direction of the opinion that the disease was possibly of fungal origin. I ventured, however, to differ with Mr. Mukharji that, in recommending a chemical treatment to be pursued, it did not matter very much, for practical purposes, which mildew it is that causes the destruction. And here I would add that it is essential before any such treatment can be recommended that we know the life-history of the organism causing the disease. I, however, concluded my remarks on this subject (in the letter above quoted) by saying that I entirely concurred with Mr. Mukharji in recommending burning as perhaps the most certain way of checking the spread of the disease. Once a palm is invaded with this mysterious disease death seems very nearly universally to follow.

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From the copy of a correspondence on this subject (furnished to me) that has passed between the Director of Agriculture and Colonel Sir George King, K.C.I.E., I.M.S., Superintendent of the Royal Botanic Gardens, I learn that he also has arrived at the opinion that destruction by fire is the only likely method of coping with the disease, until such time as we have learned the life-history of the organism that is concerned in the death of the palms.

10. ***Fungicides.***—So far as I have been able to discover, regarding the structure that is at least in fairly constant association with the destruction of the trees, no chemical treatment is ever likely to be of avail. The growth to which I allude lives within the tissue of the palm and apparently comes to the surface only (if ever) when the palm has been killed. To syringe affected trees with poisons can be of no possible advantage, either to save the individual from the certain death that is rapidly overtaking it or to check the spread of the malady. If my observations be confirmed by future investigators, that the organism seen by me within the tissue of affected palms, is the actual or even chief cause in their destruction, it might be said that it would very possibly be more effectual to pour the fungicide into the ground around the roots than to spray the domes of leaves and terminal buds. A system of spraying young trees might possibly be of advantage in killing the germs of destruction, before they have inoculated new hosts (assuming that such inoculation took place which I think not), but the course proposed would be impracticable, since it would mean the syringing of a forest of palms, each 30 or 40 feet in height. So again, allowing that it can be demonstrated that fungicides actually do arrest the disease, organic lesions of so serious a nature have been effected before the external symptoms of disease have appeared that I should very much doubt the advisability of saving such trees.

MY DEPUTATION TO THE AFFECTED DISTRICTS AND PLACES VISITED.

Deputation to Report no Affected Districts.

11. In reply to my letter of the 29th April 1896 I received telegraphic instructions to visit the districts most severely affected, and to thus conduct a personal enquiry, provided this could be accomplished within a period not exceeding one month. Mr. N. G. Mukharji was deputed by the Bengal Government to accompany me, and joined me at Barisal on Sunday, the 17th May. I availed myself of a

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BETEL-NUT PALM DISEASE.

Localities Visited.

very generous offer made me by Messrs. Hoare, Miller & Co. to travel in their steamer, the *Alokashi*, that was to sail on the 14th direct from Calcutta to Barisal. Although this occupied the greater part of two days longer than the route by train to Khulna and steamer to Barisal, I was enabled to study the Sunderbands, and as I could stop the steamer as found necessary, I had several opportunities of studying the disease in more southern parts of the Khulna and Backerganj districts than I would otherwise have had. At Morellganj we were joined by Mr. W. A. Lee of the firm of Messrs. Hoare, Miller & Co.—a gentleman who has devoted much of his leisure hours to microscopic studies, and who took accordingly the keenest interest in the investigations into the cause of the betel-nut disease. And I desire to take this opportunity of reporting that, through Mr. Lee's active co-operation, I was enabled to accomplish the work entrusted to me more rapidly and thoroughly than I could otherwise have done, since he practically placed at my disposal the resources of the Bengal Central Flotilla Company, and at the same time assisted very greatly in the numerous microscopic examinations that had to be made.

12. At Barisal I consulted the Magistrate and Collector, Mr. Beatson Bell, who, having then only just joined the district, regretted his inability to afford me any particulars. He agreed, however, with Mr. Lee and Mr. Mukharji that I had better in the first instance visit the Mendiganj sub-division, where the disease was said to be very bad. On two occasions I drove through the suburbs of Barisal in order to see the extent to which the blight prevailed in the sadar station. I was surprised to find that the betel-nut palms in and around Barisal itself were not affected.

13. Mr. Lee having placed the *Alokashi* at my disposal, we sailed from Barisal at daybreak on the 18th and anchored at Patharhat at 7 A.M. A visit was at once made to Badarpur, where the disease was known to prevail. A large number of trees were brought on board and the day spent in their examination. In the afternoon a visit was next paid to Sonamukhi, where further particulars and specimens were procured. At daybreak on the morning of the 19th an exploration was made to the more distant village of Lashkarpur—a village with a very extensive betel-nut cultivation, and where it was estimated something like 90 per cent. of the trees had been killed. At 12 noon we returned to the *Alokashi*, which at once returned to Barisal.

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The afternoon and evening of the 19th were again spent in the microscopic examination of the very extensive material that had been collected.

Localities Visited.

14. At 5 A.M. on the 20th we sailed for Noakhali, and arriving at Ichakhali proceeded by road to Noakhali. On the way various plantations were visited and many specimens collected. The 21st and 22nd were then spent in Noakhali where Mr. S. K. Agasti, the Magistrate and Collector, afforded what assistance he could. The plantations around the sadar station were visited and cultivators from more distant parts of the district brought in and interviewed. On the midnight of the 22nd we again embarked, and reached Barisal on the 23rd, sailed for Khulna on the 24th, and reached Calcutta on the morning of the 25th May.

15. I was thus absent from Calcutta in all some 10 days, and I may explain that my tour of inspection occupied a much shorter period than I anticipated before starting, but I found there was no occasion to extend the enquiry at this season of the year. Sufficient material had, moreover, been collected to enable me to work out all that was likely to be ascertained, and it was found that having seen one or two plantations and talked with some 50 or 60 cultivators, was, for all practical purposes, the same thing as having visited every affected plantation.

CULTIVATION OF THE BETEL-NUT.

Mandar and Betel Groves.

16. ***Mandar Groves.***—In the districts of Backerganj and Noakhali (and very possibly in other districts as well) the Areca palms are planted in groves of *Mandar* (**Erythrina indica**). This Papilionaceous tree is supposed to improve sandy soils and to make clay soils more pervious. The cultivators are of opinion that the leaves enrich the soil, but they affirm that shade is required until the betel-nuts are full grown. It is probable, however, that it is protection from wind storms, more than shade from the sun, that is sought.

Branches of the *mandar* some 6 feet in length are planted in rows, the branches being placed 12 to 15 feet apart each way. The planting is done in February or April, not March. By about 2 to 3 years, on high lands, and 4 to 6 years, on low lands, the plantation is ready for the betel seedlings. In certain parts of Khulna district I was told they did not form *mandar* groves, but simply planted that tree on the circumference of their estates. This system is also

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CULTIVATION OF BETEL-NUT.

followed in Kaukhali and Perozpur in Backerganj district. In the localities where that condition prevails I was somewhat surprised to find that the disease had not so far been recorded as doing serious damage.

Seasons of Sowing.

17. ***Seasons of Sowing.***—The betel-nuts are sown in October or November, the seeds being deposited 4 to 5 inches apart and the nurseries are either close to the homestead in shady places, or, if conveniently situated, the nurseries are made in the *mandar* groves themselves. The transplanting is usually done after 2 years, sometimes 3 or 4 years. For high lands the seedlings are transplanted in July, for low lands in February or April. In the first transplanting the betel-nuts are placed equi-distant from the *mandar* trees and thus 12 to 15 feet apart. But a second regular transplanting takes place when the first trees have come into bearing. Before this is done the *mandar* trees are cut down or only a fringe left around the circumference of the grove. The betel-nuts in a fully planted grove are thus about 6 to 7 feet apart each way. A certain amount of irregular planting takes place, however, as vacancies occur, and in selfishly conducted plantations the trees may be found here and there not more than 2 or 3 feet apart. It is also probable that there is a certain amount of self-sowing as it is not unusual to find two or three trees growing in a clump so close to each other that they could not be healthy. In most plantations also a distinct percentage of cocoanuts are interplanted among the betel-nuts, so that an old plantation in many cases has lost all its original regularity and become a dense jungle of palms with only a winding footpath leading to the owner's house. This generally stands on the bank of a small tank and near the middle of the holding. The holdings range from 5 to 40 acres and in the larger plantations there may be three or four tanks.

Seasons of Flowering and Fruiting.

18. ***Seasons of Flowering and Fruiting.***—These may be said to be distributed throughout the year. The flowers that form in January will ripen fruit in October; the flowers formed in March will fruit in December and January. The harvesting period is from October to the beginning or middle of January, but occasionally the new flowers may begin to form in December or January on trees from which last year's fruits have not been collected. It is thus possible to collect fruits from a diseased tree, and such are known and recognised, though not liked. (*Conf. with paras. 37-8.*)

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A Plague in the

CULTIVATION OF BETEL-NUT.

Duration or Possible Age.

19. ***Duration of Trees.***—If a few trees are planted near villages, but not in regular groves, the betel-nut may fruit when it is only 6 or 7 years of age. In plantations they rarely fruit much before the tenth or twelfth year. The trees subsequently put out in the plantation (just as the first set begin to flower) do not come into bearing for 20 years. There is no third planting except, as already stated, to fill up vacancies. Land formerly covered with betel-nuts, if replanted with them, even after a rest of several years in the form of *mandar* groves, does not, as a rule, yield until the palms are at least 20 years old.

20. It will thus be seen that it takes at least 30 years before a betel-nut plantation comes into full bearing. The fruiting life of a tree may be put at from 30 to 50 or 60 years after coming into bearing, and the total life of the tree might thus be stated at from 60 to 100 years. Several of the cultivators examined by me admitted that their plantations had been laid out by their grandfathers, if not at a still more remote time, and had continued to yield for at least the past 60 to 70 years without the slightest attention on their part, further than to occasionally top dress the soil or hoe down the weeds. But even that amount of labour is not bestowed on these profitable plantations every year, and indeed many cultivators never give any labour to their betel-nut groves.

OPINIONS OF THE CULTIVATORS

OPINIONS OF THE CULTIVATORS.

It may serve a useful purpose to record here very briefly a few of the opinions and replies elicited from the cultivators:—

Densely Planted.

21. In the Mendiganj Thana the disease first appeared in November and December of 1892, in a plantation in the village of Lashkarpur. The owner of the plantation (Alimuddin Shikdar) said that he lost about $\frac{1}{16}$ of his trees on that occasion. The disease seemed to stop for some time, but re-appeared in the following September. Before the plucking season in October 1893 he had lost about half his trees. The disease has continued ever since and he has now lost all his trees, young and old alike. He owns about 16 bighas of land, an area that, he says, formerly contained between 5,000 and 6,000 betel-nut trees.

22. None of the other gardens in the neighbourhood were seriously injured before January 1896. The first to be affected was that belonging to Shumsuddin Aken, which lies to the south. The prevailing wind in January is from the north. But very shortly after (or in fact about the same time) the plantation belonging to Nabu Shikdar and also those belonging to Nado Jemadar and to Mohammad Take, were affected, and these lie to the north.

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23. The village of Ramnathpur, which lies to the east of Laskharpur and about ½ mile distant, became attacked in January 1896.

The village of Lashkarpur may be said to have lost at least 90 per cent. of its betel-nuts, and the population have been reduced from a state of opulence to one bordering on poverty. On one occasion we came across one of the neatly built and even ornamental houses of the betel-nut cultivators deserted and empty. We asked our guide the reason, and he pointed to the forest of dead stumps of betel-nuts. The owner preferred, he said, to seek employment elsewhere rather than to face the future and have to pay rent on a useless property.

First Indications.

24. ***Indications of Disease.***—Some twenty cultivators were present when the above information was obtained. They stated that the first indications of the disease were the withering of a few leaflets (pinnæ) of one of the innermost leaves. In about 8 to 10 days the whole leaf is seen to have withered. The next leaf to be affected is that immediately outside. In about 20 to 30 days the bud and innermost leaves, which still remain green, fall off through the decomposition that is set up at the point of their union to the top of the stem. If a tree be felled just before the crown of leaves falls off, it will be found to emit an offensive smell—and the bud when it falls to the ground of its own accord gives out the same smell.

Supposed causes.

25. ***Their Explanation of the Origin of the Disease.***—The cultivators regard the disease as due to wind and damp atmosphere, connected with the cyclones that often occur about October. This followed by dry weather in February and March completes the destruction. But they were unable to account for the admitted fact that during the last outbreak it was worst during January, or just before the occurrence of the dry spring. In April they had rain and hail, after which they observed the disease began to abate, and affected trees to give indications of recovery. In Backerganj there is usually rain in January, but last year there was none, so that a want of rain up to April might be regarded as associated with the severity of the outbreak of 1895-96. The cultivators affirmed that in February and March the soil became abnormally dry, but they immediately added that they had found the disease to prevail with equal severity on plantations with damp low-lying soil and those on soil that had become completely dryed up by January and February. They would not admit having observed any special prevalence of the disease on soils of one kind more than another.

26. ***Age of Affected Trees.***—Speaking of the age of the trees affected, the cultivators first affirmed that old and young trees (even seedlings) were alike attacked. When asked the reason why the plantations through which we had marched from Patharhat to the Mendiganj Thana were

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not diseased, the cultivators replied that these were young plantations. But it may be added that they were on the banks of a river whereas those of Lashkarpur are at a considerable distance from any stream. The degree of subsoil moisture may, therefore, be assumed to be very different in the two localities. Moreover, the cultivators invariably pointed to the lowness of the water in their tanks as an indication of the untowardness of the year.

The consensus of opinion seemed, however, to be that when the disease first appeared it attacked the old trees, but that rapidly it showed no special favour for old more than young trees. Some of the cultivators even affirmed that it had appeared on the cocoa-nut palms, but the one specimen of this shown to me might have been struck by lightning, or have lost its crown of leaves from any one of many other causes. I saw nothing to justify me in thinking the peculiar disease of the betel-nuts had extended to the cocoa-nuts also, though it is significant that many cultivators affirmed that this was the case.

27. At Noakhali a large number of cultivators had assembled and the information obtained from them confirmed the above, and amplified here and there the details. The evidence of one or two may, therefore, be here given.

Sparsely Planted.

Upsaruddin, of Char Matua, had a five-acre garden containing 700 to 800 trees. The trees began to die in December 1893, a lull came about February or March; the disease re-appeared in December 1894, and went on till March 1895; returned in December 1895 and continued till March. He has only 100 trees alive now.

28. Mohammad Amjad, of Rameshwar, said, they had a cyclone in October 1893. He noticed the betel-nuts dying in November following. The leaves all turned yellow simultaneously and by February he had lost $\frac{3}{4}$ of his plants. There was again a lull till the cyclone of October 1895, when the disease re-appeared.

Another cultivator gave practically the same opinions. He had 2 acres bearing 1,500 trees, he has only about 100 left, and these are young trees, not bearing.

29. Ali Meah, of Sharla, said he had 4 acres under betel-nut. He attributed their having died to the order issued by the Collector to have them counted—he sagely remarked that "you do not count your children." He did not think the cyclone of 1893 had anything to do with the disease, for the reason that they had often before had cyclones and these were not followed by a plague. He was quite sure that Government was responsible for the plague, and remarked, "Counting with the object of increasing rent or oppressing the ryot is offensive to Allah."

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Sequence of Attack.

He added that, while young and old trees were alike affected, there was a greater percentage of death among the old. He said that it first appeared as spots on certain leaflets of the second or third leaf from the inside, but that he had also seen the bud first showing the symptoms of disease. If the innermost leaves are first attacked, the course of the disease is more rapid. From the time of first appearance it generally takes 10 to 12 days in dry weather and nearly a month in wet, before the tree is killed. The disease has for the present disappeared, in fact certain trees that were distinctly attacked, he said, had begun recently to recover. But he regards it as certain that this recovery is only temporary, that there is no real recovery, on the contrary, that those very trees will die later on in the year. He repeated when cross-questioned that the disease most commonly commenced on the second or third leaf, but that he had seen the bud first attacked, and had also observed the course reversed, the disease extending from the outermost leaf of all to the bud.

Recovers with Rain.

PRELIMINARY OBSERVATIONS.

30. Having thus mentioned the localities visited and the opinions of the cultivators, I shall now proceed to detail some of the observations made by me, but I do not think it will be necessary, except on rare occasions, to specify the localities where these were recorded.

31. My first impression was that we had to deal with several, not one disease. I asked the cultivators to point me out diseased trees and I ordered these to be cut down one by one. While that was being accomplished I questioned the cultivators as to the symptoms by which they recognised " the byaram " "(the disease)" and the only sort of opinion they could give was that the leaves had begun to wither.

Symtoms of Disease.

32. ***External Symptoms.***—In one case a few pinnæ, on the second or perhaps the third leaf from the central bud, had withered; in another the whole of that leaf had turned to a uniform reddish yellow colour, but stood erect; in a third two or three leaves were more or less withered, some having lost all shade of red, and dried up into a dirty straw colour and become pendent. But in all three examples the bud and first leaf stood erect, were green and quite healthy looking. In a fourth the terminal bud had toppled over and was suspended among the withered leaves. In still another the entire terminal crown of leaves had fallen off leaving a dead stump —a monument of the completed course of destruction.

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ARECA Catechu.

A Plague in the

BETEL-NUT PALM DISEASE.

Severity and Rapidity of Disease.

33. In every plantation all these conditions could be seen on young and old trees alike even on seedlings. In some plantations there might only be 5 per cent. of leafless stumps, in others 20, 30 50, or as much as 90 per cent. killed.

34. The malady is thus clearly a very alarming one and the history given me by numerous cultivators in every locality visited was that, from the date a few pinnæ of a leaf near the middle of the crown were seen to wither, little more than one month elapsed before the tree was leafless. I pointed out to the cultivators that the lower leaves of every palm were withered, but the answer came promptly : "that is all right, these have died from age. That is not what we mean, it is when a portion of a young leaf withers, that we recognise the first symptoms of the disease."

Direction of Withering.

35. ***Direction of Withering.***—I examined many examples, hundreds I might safely say, and in the vast majority it seemed to be the second or third leaf, counting from the central bud outwards that got first affected. But the withering was not constant in its course. A few pinnæ about the middle of the leaf, and on one side of the midrib only, would be first affected. At other times all the pinnæ on one side, or again the whole leaf, would simultaneously change to a dull sickly orange red colour, then turn bright yellow and fade into a dirty straw colour. It is noteworthy that the withering did not seem to extend gradually from the base to the apex nor *vice versâ*, but appeared suddenly and often at isolated positions. The first leaf to be affected might show but a few pinnæ in one place withered, while the next outwards had completely withered, or that course might be reversed, the innermost being in the furthest state of decay. Or again two or more isolated portions of the same leaf might be seen withered and the rest perfectly green. There were thus no direct indications of death being caused by a disease that advanced by regular stages from a fixed starting point or a number of such points.

36. The only symptom or rather nearly invariable peculiarity of the disease seemed to me to be the order in which the leaves partially or entirely withered, namely, outwards and downwards. That is to say, if it began in the second leaf from the bud, the next to be invaded would be the third, then the fourth, and so on. This struck me, moreover, as being somewhat in accord with my previous observation (*Para. 7 above*) that the upper buds were, if anything, in a further state of decay than the lower ones. I accordingly slit

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Direction of withering.

open the stems of many specimens to see the buds, but found these in no instance of the size and in the condition already recorded in connection with the sample examined on the 20th March. There were either no buds visible at all or only very minute ones not more than half inch in breadth and about an inch in length. Except in badly diseased plants such buds as were found looked fairly healthy, but in no case did I find the buds of palms freshly hewn down, to possess the maggots recorded above (*Para. 5*).

37. These observations led me to presume that the specimen examined on the 20th March had been only slightly attacked by the disease, and had, therefore, been able to form buds. But I found it extremely difficult to account for the absence of lateral flowering buds still more so for their small size, when present, as compared with those of the sample examined two months previously. And this problem was still further complicated by the entire absence of maggots from the buds or diseased tissues. (*Conf. with para. 18.*)

38. But while the majority of the palms, said to be diseased, manifested the peculiarities just detailed, there were many that the cultivators instantly pronounced as affected with the *byaram* in which the leaves seemed to have been killed simultaneously, very possibly by a storm. In such cases the terminal bud would be seen twisted and torn to pieces, the leaf-stalks (half reduced to fibrous cords) being tied around it. I was disposed to regard such examples as killed by storms, though of course they might have been diseased and weakened before the occurrence of the storm by which they were finally killed.

Constitutional Disease.

39. The absence of any fixed and readily recognisable symptoms astonished me very greatly and led me to suspect the presence of some constitutional rather than parasitic disease. With a malady of such severity and rapidity of action one would have expected definite characters, if not fixed stages of progression. The trees were dead or evidently dying, and that was all or very nearly all that could be stated. But let me repeat, in no instance did I find on the surface of the leaves or within the texture of the diseased parts, any trace of an algal or fungal parasite.

INFLUENCE OF CYCLONES.

40. The cultivators attributed the disease for the most part to the cyclones that are very prevalent in the autumn months. As just

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A Plague in the

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Influence of Cyclones.

stated there were found many dead trees with pendent crowns of leaves that might easily have been killed by the cyclone of October. In such cases the crown of leaves had not separated from the stem; the bud and leaf-stalks had not become rotten, but were dried up and reduced to a fibrous condition from being tossed about in the wind, owing to their having remained dangling to the stem for some four or five months. This is clearly a different condition from that in which the tree becomes leafless in little more than one month from the date of giving external indications of being first attacked, and where the tissues become rotten and putrid. Moreover, the continuance of the attack, trees being seen one after the other to be affected during a period of at least four or five months from the date of the cyclone, could obviously not be a direct consequence of injuries sustained at one and the same time. During the past 20 years there must have passed over the Backerganj and Noakhali districts many cyclones, but only on two occasions have these been followed by a plague among the betel-nuts.

Climatic conditions.

41. It was thus clear to my mind that by a coincidence possibly, a cyclone had preceded the out-break of the disease—a disease that probably requires for its epidemic growth the climatic conditions that follow the cyclonic period. The injury done by cyclones, where not associated with such a disease, would be regarded as ordinary casualties. The betel-nut is undoubtedly a delicate palm and would be readily injured by severe storms, so that a certain percentage of deaths very likely always follows the cyclonic period, though the cultivators take no special notice of that fact. It is only when an epidemic occurs that they become alarmed and look about for an explanation, and then the peculiarity of the disease appearing after the close of the cyclonic period may naturally suggest the cyclone as its cause.

42. The fact that the disease had spread from the districts where it first appeared, into remote regions where there had been no cyclones, would seem to dispose of the cyclonic theory. It may be mentioned that on my return to Calcutta I had diseased betel-nuts sent me from several districts, besides those of Eastern Bengal, and myself discovered a few isolated trees badly affected in gardens in Calcutta. It would be difficult to account for the communication of a contagious disease to single trees in the heart of a great city and several hundred miles away from the chief region of betel-nut cultivation—and yet I have little doubt they were killed by the same disease as that which

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raged in Eastern Bengal during the period of my tour of inspection. What is still more significant, while the disease had practically stopped in Backerganj and Noakhali, it would seem to have subsequently commenced at Sibpur near Calcutta. But if climatic conditions be assumed as possibly originating the disease, there would very probably be little difficulty in accounting for isolated and simultaneous manifestations.

PARASITIC FUNGI AND ALGÆ.

Parasites.

43. During my rapid tour of inspection to Eastern Bengal, I had ample opportunity to hunt for external parasitic organisms, and with three or four microscopes at hand could ascertain, with some degree of certainty, whether those seen could be accepted as causing, or even being in association with, the disease. I requested **Mr. Mukharji,** therefore, to re-discover and show to me the parasitic fungus to which he attributed the death of the palms. In this he failed absolutely, but accounted for his failure by the changes that had taken place during the past two months. There was of course a certain amount of probability in that explanation. It was, therefore, with the very greatest care that I examined the epidermis of the stems, leaves, leaf-sheaths, and buds, for any such manifestation, for I felt satisfied that even with the most advanced stage of such a fungus there need be no difficulty in recognising the mycelia and withered fructifications, or possibly in detecting the resting condition of the fungus. The withered and dead leaves very frequently (and dependent on the extent of their decay.) manifested certain saprophytic fungi, but neither upon these, nor on the living and dying structures, could any trace be found of a parasitic fungus that would in any way account for the destruction of the palms.

44. Indeed only one parasite was discovered, namely, the lichenoid condition of the Alga known as **Cephaleuros mycoidea.** This was seen to form on the old stems immense elevated patches (sometimes as much as an inch in length) brownish red with sometimes a dead portion in the centre and a darker outer rim. These occurred up and down the stems, and side by side with numerous patches of grey lichen. But it was also noted that the outer large green leaf-sheaths were copiously besprinkled with smaller more red-looking patches of that Alga than those seen on the stem. The small patches on the leaf-sheaths were carefully studied and

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Parasitic Alga.

sections made through them to ascertain the depth of their parasitic attachments. They were readily seen to be very nearly epidermal in their action, though the cells underneath the patches to a certain depth were often much discoloured and in some cases even killed.

I had previously had occasion to study this Alga on the tea plant, and was well aware that sometimes it became deep-seated, and is then a dangerous parasite. On the leaves of the tea bush, small round orange-red patches of this parasite, that look to the naked eye very much like little patches of a foliaceous lichen, may be found in nearly every garden in Assam, but only in one or two localities does it assume its second phase. In these localities, however, it becomes deep seated on the young twigs of the tea plant. It ceases to be a lichen-like epidermal harmless parasite and assumes its more direct parasitic condition. It does not in that case form circumscribed superficial patches, but penetrates the epidermis and emerges on the surface of the twigs in the form of an extensive pile of very minute orange-coloured fructifications. The limitation of its destruction in that case is indicated by a pronounced orange-yellow line of demarcation, separating the portion of the dead from the living twig. As it advances, the tissues through which it has passed turn livid, and soon wither up and die.

45. ***Demarcating Line.***—I have gone into these details here because in every case where the leaves of the betel-nut were seen to be killed by "the *byaram*" I observed an orange-coloured line of demarcation between the living and the dead tissues. It was only natural to infer that the agent of destruction might be recognised at that point. But I was surprised to find that many trees that gave no indication of the presence of **Cephaleuros mycoidea** possessed the line of demarcation in quite as pronounced a form as in those with that Alga in great profusion. Further, though I made many sections through leaf-sheaths that showed the **Cephaleuros** and those where it was not present, I could not detect any indications of there ever having been penetrating mycelia or other foreign organisms within the tissue of the palm. I was thus forced to the conclusion, though reluctantly, that **Cephaleuros** at least could have nothing to do with the destruction of the betel-nut palms. I say reluctantly, for I had failed absolutely to detect any other epidermal parasite on these palms and **Cephaleuros** was frequently present to a very considerable extent.

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Parasitic Alga.

46. Before leaving the subject of **Cephaleuros**, however, I would desire to add a further circumstance of no small value. I never came across a leaflet of the palm that bore the alga so that that parasite must be held innocent of the withering of the leaves in the manner described. When decay had invaded the whole leaf, and was descending into the sheath, then the line of demarcation to which I have alluded was seen to be formed. The portion of the sheath usually below that line, being still living and green, was that, and that alone, on which **Cephaleuros** was to be found.

Absence of Penetrating Mycelia.

47. But, while I had failed to discover any deep-seated action for **Cephaleuros**, I had also failed to recognise within the tissue of the palm indications of the mycelia of a fungal parasite. I must have cut and examined hundreds of microscopic sections, lengthwise and transverse, through leaf-sheaths, leaves, stems, roots and buds. In no instance did I come across the slightest indication of the presence of penetrating mycelia. This circumstance, when taken in conjunction with the entire absence from the epidermis of any fungal organisms, left no room for doubt that if the death of the palms was caused by a fungus at all it very possibly would be found to be of a very unusual type, the life-history of which in all probability would prove a new and novel story to the already long and diversified literature of plant diseases.

DECOMPOSITION OF TISSUES.

Stages in Decomposition.

48. ***Stages in Decomposition.***—Before proceeding to deal with the microscopic peculiarities of the diseased palms, I think it as well to detail certain other peculiarities. I was surprised to find the greatest irregularity in the condition of the uppermost three feet or so of the trees felled. In one with only a few leaves withered, and which I was told had only recently been attacked, I found the leaf-sheaths of the three or four leaves immediately around the terminal bud, and the bud itself, completely decomposed into a watery fluid contained within the reed-like tube formed by the remaining leaf-sheaths. As I have explained, the extremity of the betel-nut stem consists of the embracing leaf-sheaths, which, for a considerable portion of their length, constitute complete tubes one inside the other. The young stem is contained within this series of tubes for some distance, the remaining portion of the tube on the top being filled up by the

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youngest leaf of all. It is this unexpanded young leaf, standing erect in the middle of the crown, that I have for convenience designated the central bud, though it should now be understood that the bud itself is right at the base of the first leaf and completely within the tube.

Various Stages in Decomposition.

In the stem hewn down, to which I have just alluded, the central leaf stood erect though its lower half right down to the bud was completely decomposed. I collected a quantity of this liquid; it was quite clear and had next to no smell. In a short time after exposure to the air it became turbid and acquired an offensive smell.

49. In another tree, where the leaves were nearly all withered, I found no fluid, no empty tube, but the whole of the inner leaf-sheaths and bud were reduced to a pulpy white mass that gave out a most offensive and sickening smell. I looked for the maggots recorded above (*Para. 5*), but found none.

50. In a third palm, which seemed externally quite as far gone as either of the above, there was no decomposition, no smell, and the leaf-sheaths and young stem when slit open showed no discolouration. They looked in fact quite healthy.

51. In a fourth, very little affected so far as external indications were concerned, the transverse sections of the leaf-sheaths and stem showed discoloured yellow and brown spots that corresponded to the position of the fibro-vascular bundles. But there was no fluid, no rotten putrid tissue.

52. The examples three and four above, I was told, were trees that had for the present had recovered from the disease, but would have most undoubtedly died next December.

53. In still a fifth, the bud had fallen off and a leafless stump was all that remained.

The effect of decapitation is usually visible a little below the point of actual location of the bud, say two or three feet below the extremity of the tree. The first indication of this is a constriction of the stem just outside the leaves. This extends until the crown becomes top-heavy. The central erect portion first falls over and then the whole crown of leaves tumbles to the ground. The constriction of the stem continues until the stump becomes somewhat pointed and appears as if the plant had been killed by a string tied tightly around the green portion. It may then be noticed that a line of depression forms lengthwise on one side of the stump, the external ring of hard wood falling in, as it were, through the interior tissue decomposing from

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the bud downwards. It will thus be noted that here again I failed to discover any uniform process of destruction such as might be seized upon as indicative of a localised and parasitic disease. **BETEL-NUT PALM DISEASE.**

54. I had, in fact, failed to see any fixed course in the withering of the leaves; failed to find a parasitic fungus either on the epidermis or within the tissue of the plant; and I had also failed to detect any very precise course of decomposition of the tissue. There could be but two admissible explanations of these significant failures, in the face of such wholesale destruction—namely, that either the disease had run its course, and for the present at all events, had practically disappeared, or that it was a malady that might be characterised as of a constitutional character not the result of a specific parasite. The cultivators were unanimous that it appeared in December, and after March ceased to attack any more trees. It was thus certain that to study the disease with any hope of being able to discover its causation it must be taken in hand in December or January and that my visit in that case was made too late in the year. **Not of Parasitic Origin.** **Season of Appearance.**

55. But one point I feel confident in re-affirming, namely, that whatever the disease may be it can hardly be a fungus that produces penetrating mycelia and that carries its fructifications to the surface, since I was almost certain to have seen the results of such penetration or the remains of the withered fructifications.

MICROSCOPIC STRUCTURES.

56. It is necessary to examine a few of the structures of healthy plants, before proceeding to deal with pathological manifestations. As in all other palms, so in the betel-nut, transverse sections of the stem, root, or leaf, examined under a low-power microscope, will be seen to consist mainly of large thin-walled cells so loosely packed together that they leave, more or less frequently, intercellular spaces, that is to say, openings between the cells. Tissue of this nature has been designated the FUNDAMENTAL TISSUE. **FUNDAMENTAL TISSUE.**

In the root and stem the cells of the fundamental tissue are broad-oblong or rotund, and show accordingly small triangular intercellular spaces, but in the fully formed structure of the leaf-sheath the cells are sometimes linear-oblong. They are then arranged in a definite manner, and frequently manifest very large intercellular spaces from the linear cells being divergent. But the greatest possible variation may be witnessed according to the age or position of

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FUNDAMENTAL TISSUE.

the tissues examined. Thus, for example, if a series of transverse sections of the young stem be made at every inch from the actual growing apex, and for a foot or so downwards, the most marvellous transitions in form may be witnessed. So in a like manner a set of transverse sections of the outermost leaf-sheath will differ materially from those of the less mature internal leaf-sheaths. Moreover, within the same leaf-sheath considerable diversity may be witnessed in the relative developments of the various parts, according to the position from which the sections have been taken. In the one the cells of the fundamental tissue may be seen to be nearly as broad as long, in another three or four times as long as broad, meeting each other in fact at their extremities only. In still a third transverse section the cells of the fundamental tissue of the leaf-sheath may be seen to be linear-oblong, and so placed as to touch each other throughout their length, being more or less parallel to the epidermis.

The Cell-Wall. Cell Contents. Nucleus. Chlorophyll Grains. Starch Grains. PARENCHYMA PROSENCHYMA.

57. It may also be recorded, regarding the fundamental tissue, that its cells have remarkably thin *cell-walls;* that the protoplasmic *contents* are quite transparent; that an exceptionally large *nucleus* may be discovered within each cell; that in superficial structures *chlorophyll grains* are discernible; and that small round *starch grains* are present in most of such cells. This condition of the cell has been designated PARENCHYMATOUS, in contra-distinction to PROSENCHYMATOUS, in which the cells are elongated.

Starch Grains. *Conf. with paras. 60a, 74.*

58. Returning to the subject of the starch grains, it will be observed that they are very abundant in the root and mature stem, become less abundant on ascending toward the growing apex of the stem, and less abundant in the mature leaf-structures than in the young leaves. The cells of the fundamental tissue of the root and lower stem will also be recognised as containing numerous bundles of needle-shaped *raphides.*

Raphides.

These details regarding the parenchymatous tissue of the betel-nut (which might be said to apply to any palm) have been gone into here, because in the diseased condition they undergo certain very remarkable modifications.

FIBRO-VASCULAR BUNDLES.

59. ***Fibro-Vascular Bundles.***—Scattered throughout the fundamental tissue will be seen compactly built structures that manifest no intercellular spaces, and the cells of which are, for the most part, in the prosenchymatous condition. Neither nuclei nor starch

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grains are usually seen within these cells, and, moreover, many of them have been fused as it were into long tubes, or *vessels*, by the absorption of the extremities of the cell-walls. These are the FIBRO-VASCULAR BUNDLES. The micro-photograph,* *Plate I., fig. 1*, shows the transverse section of a fibro-vascular bundle in the leaf-sheath.

60. For convenience each bundle may be spoken of as consisting of three well-marked portions :—

Bundle-sheath.

(*a*) A protecting *sheath* composed of two layers of widely different cells. The cells of the outermost layer differ from those of the fundamental tissue mainly in being smaller and more closely compacted, and in being often more highly charged with starch grains. The inner layer of the sheath consists of thick-walled cells—SCLERENCHYMA. In *fig. 1* the outer layer consists of the two or three rows of small cells on the circumference: the inner layer is best seen in the dark apicular bed. In *Plate III., fig. 7*, it is beautifully shown in the healthy bundle to the right where it forms a dark horse-shoe-shaped patch.

SCLERENCHYMA.

(*b*) A series of *vessels* or tubes enclosed by thick-walled cells that are in a transitionary stage of development into vessels of the character they surround. There are usually one, two, or three large PITTED VESSELS embraced by thick-walled pitted cells—the TRACHEIDES. Below the pitted vessels are placed a series of SPIRAL VESSELS, some with the spiral deposit uniformly formed, others more open and irregular, but never ANNULAR. There may be one or two such vessels, or as many as 30 or 40 compacted together by *tracheides* in various stages of development. The series of pitted and spiral vessels with their surrounding tracheides are collectively designated—the XYLEM. In *Plate I., fig. 1*, the two large eyes near the middle are the pitted vessels and the six or seven smaller ones below are the spiral vessels.

Pitted Vessels.

Tracheides.

XYLEM.

It may be of interest to add here that it is supposed to be within this portion of the fibro-vascular bundle, mainly, that the sap rises from the root to the growing bud,

* I would here explain that I am indebted to my friend Mr. W. Simmons (Secretary of the Microscopic Society of Calcutta) for having very kindly prepared the Micro-photographs given in this paper. —*G. W.*

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though it should be recollected that no fluid passes within the vessels themselves. (*Conf. with para. 72.*) It ascends within the cellular portions of the xylem chiefly in consequence of the following forces:—

Circulation of Sap.

The Crude Sap or Ascending Current.

by the suction caused through *Transpiration* from the leaves;

by the constant adjustment of the specific gravities of the fluid contents of adjacent cells—*Osmosis;*

by the chemical affinity of cellulose for water—*Imbibition*—a power that is cosequently strongest in the cells with thick walls; and

by the law of *Capillary Attraction.*

But the vessels of the fully formed wood, more especially the pitted vessels, contain air, and only abnormally fluids or other substances.

PHLOEM.

The Elaborated Descending Current.

(*c*) Between (*a*) and (*b*) on the upper half of each bundle one or two patches of thin-walled cells will be seen. Interspaced with these cells may also be recognised numerous sieve tubes. This portion of the bundle has been designated the Phloem, and it is the region within which the descending current of sap passes—the elaborated sap—the prepared food of the plant. The Phloem is seen in *Plate I., fig. 1, i.e.*, the two circular clear spots built up of small cells below the dark apicular sclerenchyma and above the pitted vessels.

RELATIVE POSITIONS.

61. ***Staining Sections.***—The proportions of these constituents of the fibro-vascular bundles may be seen to vary greatly, but their relative positions are not susceptible of change. In transverse sections the phloem is placed above the xylem, that is to say, in the stem and root it is directed toward the periphery and in the leaf toward the lower (outer) epidermis. To assist the observer to recognise these structures, more especially when in longitudinal section, it is desirable to call in the aid of one or two staining solutions, that is to say, substances that will uniformly impart colour to certain portions of the tissues examined. It will suffice to employ for this purpose three tinctorial reagents. *Picrocarmine* will give a pink tinge to the protoplasm and nucleus of parenchymatous tissues, while *aniline-violet* will impart a bright blue to the vessels and cell-walls. *Iodine* will stain the starch grains blue and impart a rich yellow tint to lignified tissues, and colour in this way certain

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cellulose deposits not stained by the violet. With the aid of these and other similar well-known tinctorial reagents it becomes possible to distinguish the relative parts of the bundle, however disproportionately they may be developed.

The Leaf-sheath.

62. ***The Leaf-sheath.***—Perhaps the best way to examine the betel-nut is to commence with transverse sections through the leaf-sheath, choosing for this purpose the second or the third sheath (counting from the outside) and making a transverse section through about the middle length of the sheath. The fundamental tissue of the central portion of the section will be seen to consist of elongated cells arranged in a beautiful manner parallel to each other and gradually tapered in length. Two or three rows of these cells encircle each bundle, and thus produce a sort of diaper pattern with the fibro-vascular bundle as the central feature of each diamond-shaped space. As if to denote the limitations of these spaces some 12 to 16 miniature fibro-vascular bundles are arranged on the circumference, in which every third one is larger and more fully formed than the intervening pair. The micro-photograph, *Plate I., fig. 2*, shows this arrangement of fundamental tissue and fibro-vascular bundles.

Outer Margin.

63. Towards the lower margin (that is, the outer surface of the leaf-sheath) the fundamental tissue will be observed to become less methodically arranged and the cells more rounded. The bundles in this position are also smaller and more numerous though at first they are as it were more elongated (transverse section), the development being on the apex and consisting mainly in the greater production of the sclerenchymatous portion of the bundle-sheath. Ultimately the bundles, crowded towards the margin, are seen in transverse section to consist of small circular patches of sclerenchyma with or without a clear parenchymatous centre, but completely devoid of any trace of vessels. *Plate I., fig. 3,* shows this condition in a transverse section of the young leaf stalk. It should perhaps be here explained that in its course through the stem each bundle is thickest a little above its middle length, and that as it abruptly arches upwards and outwards toward the periphery, in order to pass into the leaf, or is extended downwards and outwards in the direction of the root, it is gradually tapered off in thickness. It follows that many of the small and imperfect bundles in the periphery of the stem or within the leaf, are bundles which, if traced upwards or downwards,

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would be found to be fully formed. To speak of them, therefore, as imperfectly formed is (in many cases) but relatively correct, namely, to the other bundles within the field of the microscope.

64. The *epidermis* consists of one row of closely packed minute oblong cells (with thin walls), and which show no intercellular spaces except the somewhat peculiar and abundant stomata which open into the alternate positions between the sclerenchymatous patches. Below the epidermis is placed a cuticular layer of three or four rows of small rounded cells also with remarkably thin walls, the cells being less than half the size of those of the adjacent fundamental tissue. It may be remarked that this condition should be eminently adapted to free transpiration, but ill-suited accordingly to any abnormal drought.

Inner Margin.

Conf. with para. 84.

65. Turning observation toward the upper (inner) surface of our leaf-sheath section, only a slight diminution in the size of the fibro-vascular bundles, with little or no crowding of imperfect bundles, will be seen toward the cuticular region. The cells of the fundamental tissue are, however, greatly elongated and so arranged as to repeatedly leave large intercellular spaces. The epidermis is similar to that described on the opposite margin, but the sub-cuticular layer is many times as thick as that of the under-surface. It consists of some 30 or 60 rows of greatly elongated parallel cells closely compacted together, and, in consequence, the fibro-vascular bundles are seen for the most part to be some distance from the epidermis.

FORMATION OF FIBRO-VASCULAR BUNDLES.

66. ***Formation of Bundles.***—Although it may be regarded as a slight departure from the description of the healthy tissues, that ultimately become changed pathologically, it may be here stated that the formation of new fibro-vascular bundles may be traced in either of two, if not three, methods:—(*a*) The great apicular horse-shoe-shaped bed of sclerenchyma, present in every fully formed bundle and which constitutes the inner layer of the bundle-sheath (*Para. 60 a, Plate I., fig. 1*) may be seen (on transverse section) to elongate as it were toward the periphery. Ultimately a semi-transparent spot appears within this expansion which may be observed to gradually assume the condition of the phloem. In course of time these new centres are severed from the old bundles, and in longitudinal sections (through the thickness of the leaf-sheaths) such new bundles appear as branches, which may be even traced obliquely through the tissue until they enter into fusion with other bundles,

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thus producing an anastomosis of the fibro-vascular system. But this condition, so far as the leaf-sheath is concerned, will be observed to be most frequent within or adjacent to the sub-cuticular region where, as already stated, numerous imperfect bundles are crowded together. Similarly, the branching and anastomosing of bundles within the stem occurs in the bark-like zone of crowded bundles—a region in which extensive beds of sclerenchyma may be witnessed, due to the fusion of bundles (*Plate I., fig. 3*). But at the nodes (or joints) an even more complete system of branching may be traced, where a perfect plexus, as it were, occurs, that gives to the leaves secondary branches from the fibro-vascular system of the stem.

Anastomosis of Vessels.

(*b*) But to return to the subject of the formation of new bundles. In the second place, bundles may be seen to be formed from minute patches of the peculiar prosenchyma here dealt with, which originate within the fundamental tissue and gradually develop into bundles. These may have been cut off at an early stage of their existence from the bundles before the formation of a phloem, or they may have been spontaneously formed in the fundamental tissue. As seen near the outer margin of the leaf-sheath or on the periphery of sections of the stem, the majority would appear to be formed from the apex (transverse section) of the older bundles immediately behind. They very frequently remain for a period without showing any phloem, and may even expand and coalesce into great irregular beads of sclerenchyma immediately underneath the cuticle, without manifesting any tendency to form definite bundles.

(*c*) It would also appear probable that bundles originate by a third process, namely, the formation of a band of cells that assume the conditions of the phloem, and ultimately become surrounded by a prosenchymatous sheath.

67. ***Occurrence of Vessels.***—In point of time and place the spiral vessels are first to appear within the bands of sclerenchyma destined to be converted into fibro-vascular bundles. The pitted vessels are formed at a much later period, their presence denoting fully formed bundles. A few of the interior sclerenchymatous cells of the young bundle assume the condition of tracheides, and others gradually form spiral vessels. But prior to the appearance of vessels a central phloem has invariably been formed. It is thus evident that the essential conditions in the formation of a fibro-vascular

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bundle are a well-developed sheath of sclerenchyma surrounding a parenchymatous central cord. The precedence of these conditions is so invariable in all the younger tissues, that the fibro-vascular system in its ultimate extensions and anastomoses may be said to be represented by cords of sclerenchyma, with or without a parenchymatous central band.

68. ***Bundle-sheath.***—The sclerenchyma of the inner layer of the bundle-sheath may readily enough be recognised. Its cells are made to assume a greenish tint by picrocarmine and are then seen to form a peculiar horse-shoe-shaped apicular cap on the top margin of the transverse section of the bundle (*Plate I., fig. 1*), the dark portion at top of bundle. From the centre of this embracing concavity a dividing band of cells penetrates through the pink-coloured parenchyma of the phloem, and on nearing the xylem gradually spreads out and becomes less and less prosenchymatous, until ultimately it merges again into the condition of the tracheides around the vessels. Under the influence of iodine the apicular cap of sclerenchyma turns orange yellow, the remaining portions canary yellow, while the phloem is not stained.

Right at the further extremity of the bundle there is a similar sclerenchymatous horse-shoe-shaped embracing bed, though very much less distinct than the apicular one, and with the majority of its cells stained by iodine yellow instead of orange. In *Plate I., fig. 1*, this is not very distinct, but is indicated by the dark cells near the limitation of the bundle. These two beds of sclerenchyma may almost be said to be connected by two chains of prosenchymatous cells that complete the inner sheath. Within this sheath there may be seen a fairly large patch of thin-walled cells, of a more or less parenchymatous nature, that extends from the lower cap of sclerenchyma to the tracheides of the spiral vessels.

69. Outside the sclerenchyma may be recognised the outer layer of the bundle-sheath. This is purely parenchymatous, it belongs to the fundamental system, but is clearly adapted as a special limiting layer to the bundle. The cells are much smaller than those of the fundamental tissue, and, as seen in longitudinal section, are greatly elongated. On the apex of the bundle this outer layer of the bundle-sheath is most highly developed, and in the case of the bundles met with in the stem where it may be seen to have developed into many times the size of all the other portions of the bundle viewed

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collectively. This condition is very well shown in the micro-photograph (*Plate II., fig. 6*), where the spiral vessels and cells of the xylem are dark coloured through the presence of a deposit within them.

70. ***Structure of the Stem.***—In fact the apicular parenchymatous sheaths have expanded into immense patches each with its dwarfed xylem and phloem thrown into the lower extremity. The fundamental tissue of the stem has thereby been compressed into narrow dividing ridges between these great oblique expanses of small-celled parenchyma (*Fig. 6*).

71. Moreover, transverse sections of the stem might, near the apex, show many bundles almost lengthwise, owing to so many in that position having turned acutely outwards to enter the leaves. In this condition the parenchyma of the outer bundle-sheath is not only revealed as made up of elongated cells, but the nuclei of adjacent cells occur uniformly in the same positions, and thus give these ribbon-like bands of elongated cells a jointed appearance when viewed by a low power. When it is recollected also that new bundles can be seen to be thrown off from the sclerenchyma, and that at the joints (or nodes rather) of the stem numerous branches may be traced, it becomes apparent that the immense development of woody tissue (the sclerenchymatous inner layer of the bundle-sheath (*Plate I., fig. 3*) and the equally great production of the parenchymatous outer layer of the sheath (*Plate II., fig. 6*) must be intimately connected with the life of the plant.

72. ***Circulation of the Sap.***—I am thus disposed to regard the view advanced by many botanists (*paragraph 60*), that the ascending crude sap passes within the xylem and the descending elaborated fluid within the phloem, as very possibly too circumscribed. Those divisions of the bundle are doubtless primarily concerned in the circulation, since in many parts of the plant (as in the leaf-sheath and leaves) the vascular system consists mainly of a series of what might be designated theoretical fibro-vascular bundles. But a very much larger proportion of the palm tissue consists of the sclerenchyma of the sheath than of the xylem of the bundles. It is accordingly difficult to believe that the theory of imbibition should not be admissible as operating powerfully within bands of tissue of this nature, the more so since these manifest within the external structures an almost complete anastomosis, and are exceptionally highly developed in the root. In the same way I am disposed to regard the distribution of the elaborated sap within the stem as passing to some extent at

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least through the so-called parenchymatous outer layer of the bundle-sheath, seeing that the phloem of the bundles of the stem is relatively very minute. In the root it is otherwise; the descending current of elaborated sap apparently passes exclusively within the phloem of the more central fully developed bundles. And, in part support of this view of the parenchyma of the bundle-sheath, I would mention the further fact that the formation of starch grains and raphides is mainly (one might almost say entirely) within the fundamental tissue of the stem and root, whereas in the leaf, starch grains may be witnessed as most abundant in the parenchyma of the outer zone of the bundles.

73. ***Formation of Lateral Flowering Buds.***— Before passing to the consideration of the morbid structures it may be as well to mention, in conclusion, that in longitudinal sections through the terminal bud of the betel-nut palm, the formation of the flower buds may be traced. From the base of each leaf, on its inner face, and distinctly above the level of the apex of the stem, a small portion of the cellular tissue of the leaf may be seen to be severed. This becomes the protecting sheath of the flower bud. In the interior of the sheath a miniature bud, very much like the terminal leaf-bud, is gradually formed, which has minute leaves embracing its apex, but at this stage the vascular plexus may be observed to have furnished no offshoot for the young flower-bud. It is composed at present of cellular tissue only, and indeed the vessels that enter the leaf from the stem are seen to cut abruptly across the base of the young flower-bud. Even the vessels of the leaf, however, may be observed to be but imperfectly formed. They consist for the most part of cords of sclerenchyma with only occasionally one or two minute spiral vessels.

MANIFESTATIONS OF DISEASE.

74. ***Nucleated cells within the Pitted Vessels.***—I have gone into the details given in the last chapter, because it seemed necessary in order to follow the probable course of the disease that the study should start from some knowledge of healthy tissues. Mention has been made (*Para. 6*) of remarkable nucleated cells seen within the pitted vessels. Without venturing here to express any definite opinion as to the nature of these organisms, I would remark that I have not found them invariably present. Trees have been brought me as diseased in which I could find neither the nucleated cells of the pitted vessels, nor any of the other morbid conditions to

Conf. with Plate II., figs. 4 and 5.

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NUCLEATED CELLS.

be described. And again, other trees have been examined by me in an advanced state of decomposition, but in which I failed to find the nucleated organisms within the pitted vessels. But, on the other hand, I failed also to discover a plant which, from external manifestations, might be described as intermediate between the two extremes indicated, that did not show a large percentage of its pitted vessels more or less completely obstructed with these organisms. In certain advanced stages I also recorded the existence of nucleated cells within the spiral vessels, and I thus became fairly convinced, after a very extensive series of observations, that their disappearance from the pitted vessels was coincident with the appearance of other abnormal conditions within the trachea, tracheides and spiral vessels.

75. When witnessed within pitted vessels that are only partially filled, the organisms that have been spoken of as nucleated cells are at first perfectly spherical. (See the two pitted vessels in the centre of *Plate I., fig. 1.*) They seem to be produced from the inner wall of the vessel and to be surrounded by a remarkably thin cell-wall. When fully developed, however, they become very large, considerably larger, as Mr. George Massee of Kew remarked to me (on his examining my microscopic sides), than the spores or cells of any known fungus. As they enlarge, the nucleus becomes distinctly visible in each cell, and on the cells from opposite sides of the vessel meeting they lose their spherical form and become closely compacted together. They are quite transparent, so that by turning the fine adjustment of the microscope, others, and still others, are brought into view as observations is carried down the vessels.

The micro-photographs (*Plate II., figs. 4 and 5*) show these remarkable and very large cells completely filling up a pitted vessel.

76. ***Plasmic coating.***—It will be recollected that the old pitted vessels contain air ; that in exceptional conditions only do they possess fluids ; and that, so far as is known, they have rather a structural than a vital *rôle* in the economy of plant life. It would, however, be contrary to all experience to suppose that these vessels could be completely filled up with foreign organisms, in the way shown by the photographs (*Figs. 1, 2, 4 and 5*) without the life of the plant being thereby seriously disturbed. Moreover, plants in a further stage have been repeatedly seen by me to manifest a very different condition of pitted vessels. The internal walls of these vessels have been observed to be coated with a thick yellow brown layer that manifests

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a slightly granular condition, but is not built up of cells or other recognisable organisms.

77. Coincident with this change in the pitted vessels the surrounding tracheides have been observed to be filled with a dark-brown substance, and a few, or, in advanced stages, all the spiral vessels, similarly entirely choked up with a thick yellow-brown plasmic deposit that in longitudinal section may be traced along the vessels as interrupted blocks of various lengths. This condition is seen in the micro-photograph (*Plate II., fig. 6*) of a transverse section showing the spiral vessels and xylem cells of a bundle filled with such deposits.

78. In time the walls of the pitted vessels of the tracheides and of the spiral vessels become absorbed, and the entire xylem is thus converted into a large irregular tube, the circumference of which is then seen to be lined with the thick yellow-brown (and, in advanced stages, reddish-brown) plasmic substance already mentioned.

The micro-photograph (*Plate III., fig.* 7) shows the xylem of fibro-vascular bundle destroyed, but with a few fragments of the spiral vessels floating in the long irregular channel and with the half-absorbed pitted vessel pressed against the phloem.

79. ***Xylem destroyed.***—It may also be noted (*fig.* 7) that the phloem is not seriously involved in the destruction, and that quite near are two perfectly healthy fibro-vascular bundles, one of which shows a very large pitted vessel which does not contain nucleated cells. This bundle also very beautifully exemplifies the inner sclerenchymatous layer of the bundle-sheath, separating the phloem from the immensely developed parenchymatous outer layer of the sheath.

But the destruction of the xylem, it will be observed, has extended downwards and obliterated the whole of the lower portion of the bundle-sheath. The adjacent cells of the fundamental tissue around the bundle have also been discoloured, their contents contracted and their nuclei have disappeared. These cells have, in fact, been converted into store-houses of reserve material to be used up with the progress of the disease. The transverse section of a diseased fibro-vascular bundle, as seen under the microscope, might thus not inaptly be compared with a great open ulcer.

80. ***Gemmation.***—Within the ulcer-like opening formed through the absorption of the vessels and the amalgamation of the yellow-brown deposits formerly contained within these, I have repeatedly seen spore-like bodies developed from the plasmic beds of

DESTRUCTION OF XYLEM.

yellow and brown matter. These were thrown off from chains of similar bodies by a process of gemmation. I have called these spore-like because I failed to detect in them the nucleus, so strikingly present in the early stages of the disease. (*Plate III., fig. 8.*) They measured $\frac{4}{1000}$ths of an inch in length and a little more than half that in breadth. They were seen to be globular bodies often borne upon rather stout peduncles. The chief points of interest would seem to be that in no case did I find these so-called spore-like bodies in association with nucleated cells within the vessels. But in every instance, where I did discover them, the cellular tissue for a considerable distance around was highly charged with transparent minute spherical bodies which I shall call sporules. These ranged from $\frac{1}{2000}$th to $\frac{1}{4500}$th part of an inch in diameter. The cell contents had also contracted or entirely disappeared. The so-called sporules were also seen to be reproduced by gemmation and to emerge from the cells by rupturing the cell-walls.

The following sketch may be given as conveying the appearance of these so-called spores and sporules greatly magnified as seen in longitudinal section through diseased fibro-vascular bundles:—

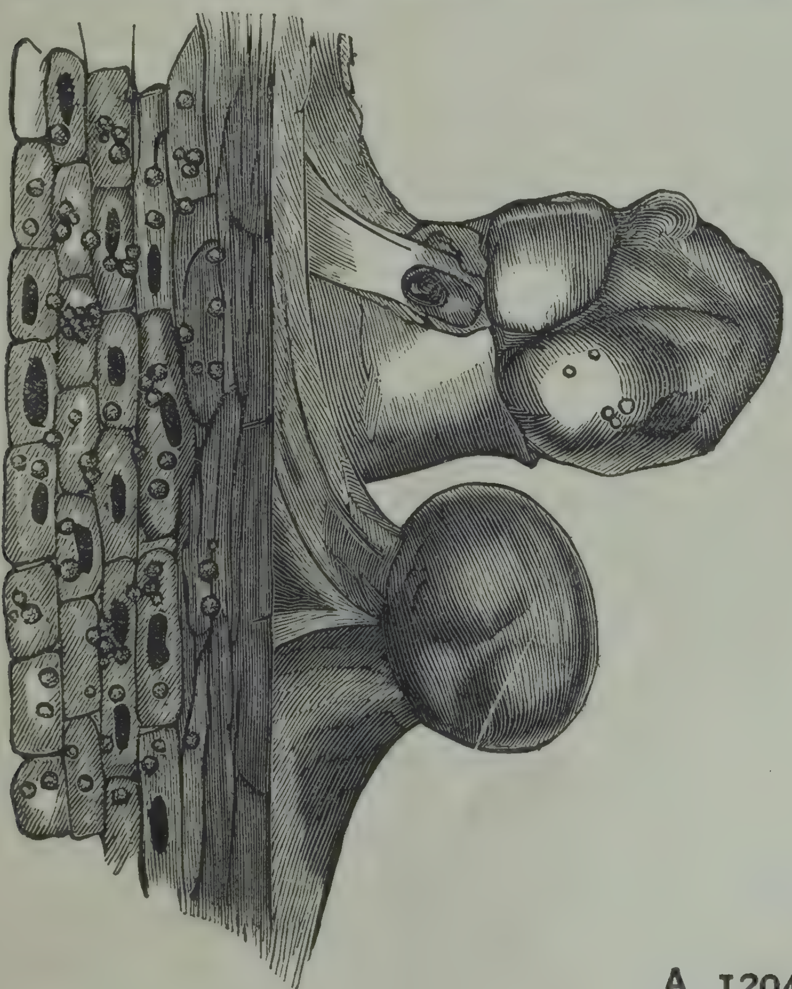

Fig. 10

Shows the sporelike formations within the xylem and sporules in adjacent cells.

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SPORES AND SPORULES.

The micro-photograph (*Plate III., fig. 8*) shows the so-called spores within a transverse section of a diseased and obliterated xylem of a fibro-vascular bundle.

The yellow and red tints of these formations rendered it next to impossible to photograph them; it was on that account that I made a drawing with the camera-lucida of the longitudinal section (shown in *fig. 10*). The transverse section (*fig. 8*) manifests, however, all trace of the fibro-vascular bundle obliterated and some three or four spore-like structures growing inwards from the wall of the irregularly shaped cavern that has taken its place.

81. I was unable to establish any direct connection between these spore-like bodies and the nucleated cells that had preceded them, but I have little doubt in my mind that they are connected, and that the so-called nucleated cells may be but an earlier stage. But if this view be not confirmed, there would seem no doubt that the distribution of small transparent sporules or vesicles through the tissue of the plant is directly connected with the production of a plasmic lining to the vessels and the formation on its surface of the structures I have spoken of as spore-like bodies borne on stout peduncles. At the same time, however, I obtained indications that the formations of these sporules may not be entirely dependent on the existence of my so-called spore-like bodies.

Vesicles.

82. ***Minute Sporules or Vesicles within the Tissues.***—In badly affected parts the contents of the cells of the fundamental tissue will be seen to have become contracted and reduced to flat solid structures not unlike minute plasmodia and that all traces of their nuclei have been lost. The cell-walls may also be observed to be perforated, so that it is clear a foreign influence has been passing from cell to cell. At a certain stage in this disintegration it will be discovered that minute round clear sporules or vesicles are formed from the plasmodial cell contents, and that these at once commence to gemmate and throw off smaller sporules. They may also be witnessed to pass through the cell-walls and to accumulate in the normal or within artificially formed intercellular spaces—spaces formed through the complete destruction of cells that have already discharged their sporules. This destruction will, on longitudinal section, be seen to very frequently follow the line of the fibro-vascular bundles, though ultimately it extends through the tissues irregularly.

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The micro-photograph (*Plate III., fig. 9*) shows one of these irregular caverns penetrating through the tissue. It has involved two rows of cells at one part and three at another. Unfortunately the photograph does not bring out the multitude of transparent sporules packed within the cavern and oozing through the cell-walls. It shows, however, very clearly the discolouration and contraction of the cell contents into what I have called plasmodial-like thick dark-brown patches.

83. The following drawing made by means of the camera-lucida represents a similar cavern magnified 220 diameters. The sporules are there shown within the cavern, some of them undergoing gemmation. The ruptured cell-walls may also be witnessed as projecting within the cavern.

FIG 11.
Cavern filled with sporules or vesicles.

Fig. 12 represents a photographic enlargement, to four diameters, of a micro-photograph (×220) of a portion of a similar cavern to fig. 11. The drawing shows the contents of all cells contracted and darkened to the greatest extent remote from the cavern. One of the cell-contents is seen to bear a completely formed sporule (although the cell-wall would seem to be quite intact), while within the cavern numerous chains of sporules are visible.

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DESTRUCTION OF TISSUES.

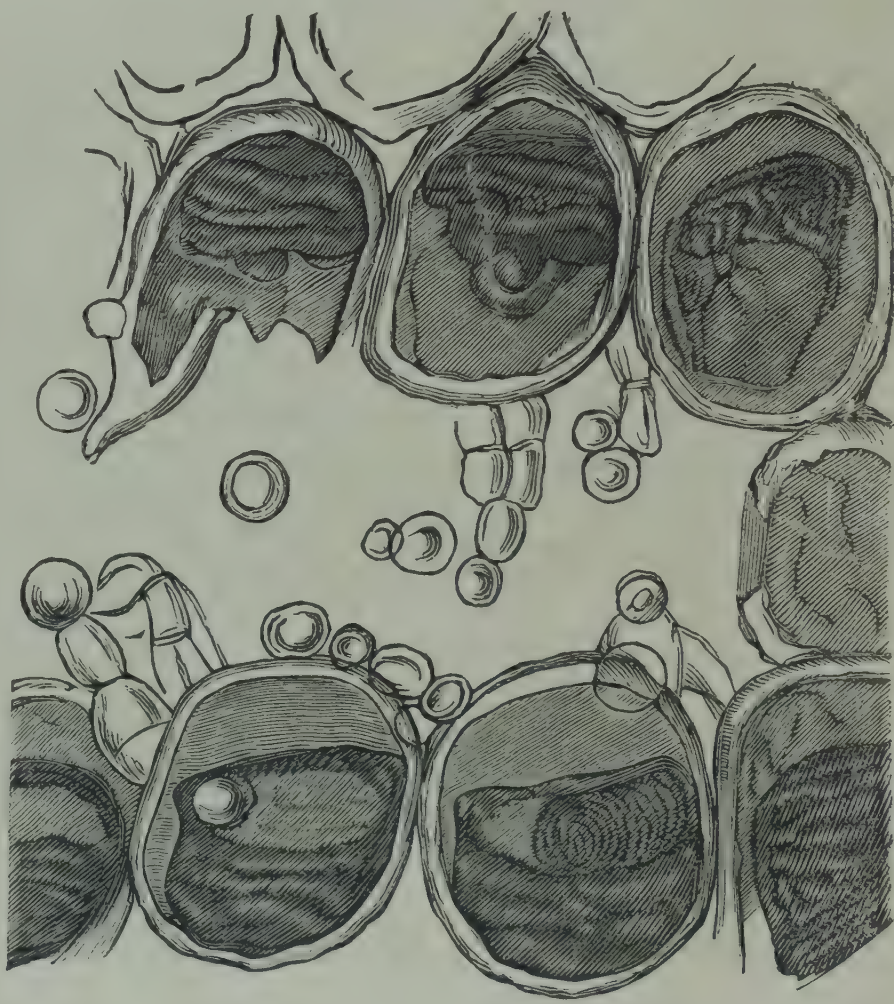

FIG. 12.

Sketch of portion of Cavern (× 220) with gemmating vesicles, enlarged photographically to four diameters.

It may be useful to exhibit a transverse section (*Fig. 13*) through the structures permeated with sporules. These minute bodies will be observed to be in some instances within the cells and free, at others arising as it were from the contracted contents (x. x. x.) while in still a third condition they have escaped into large irregular intercellular spaces (*a*, *b*, *c*, *d*). In one of these intercellular spaces (*a*) a large spore-like body borne on a strong peduncle will be noted. But in no instance are the sporules seen to be formed like hernia from the cell-walls. They are fully formed before they attempted to penetrate through the pores or ruptured openings of the cell-walls.

FIG. 13.

Destruction of fundamental tissue by sporules.

84. Under paragraph 65 a brief account has been given of the upper epidermis and cuticle of the leaf-sheath. This has a somewhat curious bearing on certain further particulars that have now to be recorded. It is very commonly the case that a waxy looking substance is found spread out irregularly over portions of the base of the leaf-sheath but upon *the inner surface only*. The first stage in the extravasation of this waxy matter appears to be the formation of minute glistening blisters, which coalesce and then dry into the waxy brown coating. Beneath this external formation the cells of the leaf-sheath are invariably found to be discoloured and to have their contents contracted into flat thin plasmodia-like structures.

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EXTERNAL DEPOSITS.

But the cuticular layer of the leaf-sheath being composed of long and closely compacted cells seems to resist the action and the discoloration accordingly passes in an arched manner towards the epidermis, enclosing thereby portions of the cuticle that remain more or less unaffected. Assuming that the external deposit is derived from the tissue of the leaf-sheath, the passage toward the surface would thus seem to be made through the fibro-vascular bundles that every now and again arch acutely toward the surface. I failed, however, to find either the external deposits or the subtended discolorations of the cellular tissue, on the outer surface of the leaf-sheath, a circumstance that it is difficult to account for, seeing that on that surface the bundles come close up to the epidermis.

85. ***Thick-walled Cysts.***—In many cases also it was observed in tissues adjacent to the condition just described that instead of forming flat biscuit-looking structures, the cell-contents had become transformed into large perfectly spherical bodies that might be spoken of as resembling thick-walled cysts. But it was by no means an unusual occurrence to find one of these dark brown and sometimes bright red cysts to have its contents arranged into 2, 4 or more daughter cysts, or to discover cells that had burst and discharged their cystic contents.

86. On several occasions I placed sections with the cells charged with these so-called thick-walled cysts, under continuous microscopic observation—the sections having been prepared in sterilised distilled water. In a few hours they lost their colour and seemed to disappear. I failed, however, to discover their assuming an amœboid plasmodial condition, but in every case the fluid around the sections was shortly afterwards seen to be alive with a fermentative germ, probably Bacterium Aceti.

87. ***External Deposits.***—These observations led me to examine with considerable care the waxy exudation described above. A few of the young glistening blisters already mentioned were pricked with a fine needle, and the substance thus removed was communicated to a drop of distilled water. It was then found to be literally alive with thousands of a minute elliptic-oblong unicellular Alga. The older plasmodial-like exudation was also examined. It was seen to be very hard and tough, in advanced conditions turning black and resembling pitch. On the surface what looked to the naked eye as a crystalline deposit was repeatedly noted. A scraping with a needle proved this, however, to be made up of great colonies of the

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INOCULATIONS.

Alga already mentioned. After being in water for some time these seemed to have all given origin to smaller and more circular cells and the liquid was also seen to swarm with the Bacterium already recorded. (*Conf. with 96—2*).

88. ***Inoculations.***—In order to obtain some indication of a connection, if any, between the two sets of observations recorded, *viz.*, observations in (*a*) the fibro-vascular bundles, and (*b*) in the cellular issue, I next proceeded to inoculate, under the microscope, sections of healthy betel-nut tissue which were kept under continuous observation. I also placed in sterilised distilled water cultivations in test tubes consisting of thin sections and also large pieces of healthy betel-nut tissue, one set inoculated with portions of fibro-vascular tissue showing the spore-like bodies (*Para. 80*) and others with cellular tissue showing sporules (*Para. 82*). In no case was I able to produce the diseased conditions. Nor in fact was I able to cause the healthy cells to have their cell-contents discoloured and contracted in the manner described. But when I inoculated healthy tissue with the Alga and Bacterium found in the external deposits (*Para. 87*) the tissues were rapidly destroyed.

I also experimented with a number of healthy betel-nut palms growing in flower-pots. I inoculated these in every way I could think of from diseased trees, but I failed absolutely to communicate the disease to them. These latter experiments were conducted for some time and now after four years the plants so treated are as vigorous as ever and have given not the smallest suspicion of having become diseased.

These results were naturally both most surprising and disappointing. I had witnessed hundreds of acres of palms killed outright by a disease that I could neither produce laboratory cultures of nor communicate to healthy plants.

89. ***Offensively Smelling Fluid.***—I have hitherto only attempted to detail what I saw, and there is a further circumstance that should accordingly be mentioned. It will be recollected that badly diseased trees were often found to contain a large amount of an offensively smelling fluid within the leaf-sheath (tubular chamber) and that this was produced by the decomposition of the terminal bud. This fluid was found to be literally packed full of large elliptical semi-transparent bodies, very similar to those I have designated as algal cells seen in the waxy exudation. An ordinary sized tree might easily

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OFFENSIVELY SMELLING FLUID.

contain a pint of the fluid referred to, and the point of a needle dipped into it would suffice to bring up many thousands of these organisms.

90. ***Bacterium in Association.***—There is one other circumstance that I think it necessary to add, namely, that, in the fluid just mentioned, I found in great profusion a **Bacterium,** possibly **B. Aceti.** It was, moreover, almost impossible to prepare any microscopic sections of betel-nut tissue, without these energetic organisms being found dancing about everywhere. They are doubtless the putrifactive agents that bring about the final destruction of the tissue. It seemed fairly certain from my study of the Bacterium that it very possibly has no other relationship, and that it is to the Bacterium that the offensive smell of the fluid and of the decomposing tissues is due. (*Conf. with para. 96.*)

91. ***Summary.***—By way of summing up these remarks it may be said that the sporules, found within the tissue, were most prevalent in the young leaf-sheaths and were only occasionally seen in the stem. That the deposits within the fibro-vascular bundles were more abundant in the chief bundles of the leaf than in the minor ones and more frequent in the older leaves than in the young ones. Similarly, they were more often seen in the well-formed bundles of the stem than in the immature ones. If it be accepted that the particulars already detailed give sufficient ground for supposing that there is a direct connection between these pathological conditions, then it might be reasoned that the trees are literally starved. The xylem of the more important bundles being filled up with foreign organisms that presumably use up the crude sap, the top portions of the stem (the inner buds and leaves) would naturally suffer first since these being young and growing require a larger supply of nourishment than the older, and nearly mature, leaves and buds. The circumstance that the disease does not attack simultaneously all fibro-vascular bundles may be accepted as explaining the somewhat erratic way in which certain pinnæ (*Para. 35*) of the leaf are seen to wither while for a time others remain green.

In part support of these conclusions I need hardly perhaps repeat that the location of disintegration within the topmost portions of the stem was most striking. It was not an unusual occurrence to find the terminal bud with all its leaves completely decomposed, whereas, two or three inches below, the stem was found comparatively healthy

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FERMENTATIVE AGENTS.

looking, or to only manifest a few fibro-vascular bundles with deposits within their vessels.

92. But, I wish to reiterate the opinion I have already expressed, namely, that, in order to trace out the history of this very remarkable and alarming disease, it is essential that the study should be commenced in November or December. I have failed to verify some of my observations by actual inoculations, possibly owing to the fact affirmed by the betel-nut cultivators that the disease had reached its inactive stage by the time I was deputed to investigate it. I have, therefore, attempted to detail what I saw, not what I have proved. I have done so in the hope that my observations, and even speculations, may direct the attention of others to certain features of the disease, or, at all events, to certain morbid formations that are in intimate association with it. These should be demonstrated as unconnected with the disease or as only secondary consequences of it, if that be so; but I personally am strongly disposed to think that the complete obstruction of the xylem is quite sufficient to account for the subsequent destruction of the palms. The growing parts are thereby starved and death rapidly supervenes. This is instantly accompanied by the fermentative Bacterium and the Alga already described when the disintegration of the tissue and the production of an offensively smelling fluid is the natural consequence.

RÉSUMÉ OF IMPORTANT OBSERVATIONS.

Climatic Conditions.

93. ***Climatic Conditions that Favour the Disease.—Review of Facts stated.***—I have demonstrated my failure to detect the presence of any parasitic organism. On the other hand, in paragraph 7, I have shown that the buds within the terminal closely embracing leaf-sheaths were always most diseased. This might possibly be accepted as denoting the absence of any external infection. Paragraph 25 points out that the soil of the great betel-nut area is very little above inundation level and for a considerable part of the year the roots accordingly may be regarded as practically standing in water. The rainy season may be said to terminate in October. The level of the rivers then rapidly falls and the soil gets dried up. But there is usually a little rain in January. When this fails and the hot season approaches, the soil becomes abnormally dry and parched. At the same time the atmosphere is rendered extremely dry and hot. Excessive transpiration

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Résumé of Important Observations.

RESUME.

ensues and the demand for moisture from the soil becomes very great.

Rain fell in April and May of 1896 and the disease was recorded to have at once abated. The soil was moistened and the atmosphere had its temperature lowered and its humidity raised.

Sub-soil moisture.

Paragraph 26 points out that one belt of betel-nuts was observed to be free from disease, while several other plots not very remote were practically destroyed. But the healthy plot was in close proximity to a stream, whereas the diseased plots were remote from water. This circumstance may be accepted as denoting the necessity for sub-soil moisture in betel-nut cultivation. Plots of betel-nut of, say, from 5 to 40 acres each have one or several tanks in the middle or here and there (*Para. 17*). During my tour through the betel-nut area the cultivators invariably pointed to the circumstance that their tanks were either dry or so low that they were useless. This circumstance may be accepted as pointing to the necessity of water at the roots of the palms during the hot months.

Favourable Conditions.

Paragraph 29 shows that it is believed the disease prevails more in dry than in wet weather, and that it very often follows abnormal climatic conditions. Rain in fact was universally admitted as checking the disease, but if once started there would appear to be only a temporary cessation of activity through the fall of rain, the disease returns again with the succeeding hot weather. It would thus appear that the conditions that favour the initial production of the disease do not frequently prevail, but that when once started the disease continues for several years, being renewed by climatic conditions that would not suffice to originate it.

Paragraph 35 deals with the fact that while the actual bud within the terminal leaf-sheaths may be completely decomposed, only the second or it may be the third leaf below gives indications of the presence of the malady. This might be regarded as due to the nucleated cells (*Paras. 6 and 74*) finding readier ingress to the more fully developed bundles of these leaves. The terminal bud may be supposed to be thereby completely cut off from supplies of crude sap.

Transpiration from Leaves.

Paragraphs 48 to 53 demonstrate that vigorously active decomposition is at first confined to the young growing parts of the stem. On the other hand, paragraph 64 may be accepted as pointing to the probability that the stomata of the betel-nut leaf favour a high

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transpiration in normal seasons, but would very possibly be ill adapted to abnormal draughts.

Paragraph 74 deals with the circumstance that the nucleated cells are not invariably present. They are in fact nearly always absent in advanced stages. It is thus probable that the obstruction of the pitted vessels may so interfere with the life of the palm as to give origin in rapid succession to the other and more destructive conditions already detailed.

Constitutional Disease.

I have suggested that the betel-nut plague may in reality be viewed as far more of the nature of a constitutional malady than of an infectious or contagious disease. And this is the opinion which I venture to think must be upheld. It is clearly originated by climatic conditions and conditions that do not occur frequently. Within the memory and traditions of the cultivators there have been one or at most only two previous out-breaks during the past 100 years.

PROBABLE NATURE OF THE DISEASE.

94. ***Probable Explanation.***—There would appear to be little doubt the disease is due to a pathological condition that has come to be known as **Tyloses.** Briefly this may be described as the destruction of the vascular by means of the fundamental tissue of the plant, a condition brought about by certain unfavourable climatic states.

The origin of the name **Tyloses** seems to be unknown. The pathological condition indicated, we are told by **Sir William T. Thiselton-Dyer** (*Journal of Botany, Vol. X.,* (*1872*), *pages 321-23*), was first mentioned by **Malpigi** (1686) in his *Anatome Plantarum* (*Vol. I., tab. 6*) as seen in the oak. The next paper on the subject would appear to have been an anonymous article in the *Botanische Zeitung* for 1845, supposed to have been written by the **Baroness Hermine von Reichenbach.** In this paper the cells seen within the pitted vessels are designated **Thyllen.** **Mohl** (in the *Ray Society's* Volume for 1849) published his Memoir on the Palm Stem. He there alludes to having witnessed " Vesicular Cells " in the pitted vessels of **Corypha cerifera.** He then adds, " I have not traced the development of these cells in the palms. Doubtless they have the same character as in Dicotyledons, in regard to which, from recent researches, * I think that I am not wrong in assuming that they are

* Doubtless the Baroness von Reichenbach's paper that described the condition seen in the Vine, etc.

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Probable Nature of the Disease.

TYLOSES.

produced by a protruding expansion (a kind of hernia) of the adjacent cell, which penetrates the pore, and either tears through or causes the absorption of the primary membrane of the vessel."

I do not propose to discuss the entire literature of this subject, but think it sufficient to quote another passage from **Sir William Thiselton-Dyer's** most admirable review. He writes, "For some information about two other papers on the nature of *Thyllen*, I am indebted to my friend **Mr. Archer** of Dublin; and as I am unable at the present time to examine these papers in detail, I shall take the liberty of using what he has told me about them. The first is by **Bohm**,* who appears to have held, according to the account of the next mentioned writer, that the so-called *Thyllen* do not originate by bulging out of the cells surrounding the ducts, but by accumulation of *plasma* between the *lamellæ* of the walls of the vessels whose innermost layers grow out as the membranes of the *Thyllen* cells. These views have been combated by **Reess** in the *Botanische Zeitung* for 1868 (pages 1-11). According to him "Each young *thylle* makes its appearance as a bulging of a wood-parenchymatous or medullary-ray cell forced through a pore in the vessels." **Sir William Thiselton Dyer** then adds, "**Reess's** views and figures are quite consonant with what has been stated by **Mohl** and described and figured by the **Baroness von Richenbach**. According to **Reess**, the communication between the *thylle* and the mother cell persists for some time, the *thylle* growing considerably, becoming filled from the contents of the mother cell, and not rarely forming a secondary nucleus. The *thyllen* are finally shut off from the mother cells, and **Reess** supposes their object to be the storing-up of starch, which appears to me a somewhat doubtful hypothesis." (*Conf. with paras. 58 and 60 a.*) **Sachs** (Lectures on the Physiology of Plants, translation 1887, page 851), speaking of the parenchymatous tissue found within the vessels of Dicotyledons, says that the cells seen "arise in fact by the very thin closing membranes of the bordered pits, at the spots where the vessels abut on soft parenchyma cells, becoming forced into the cavity of the vessel under the turgescence of the latter, and then beginning to grow vigorously. A club-shaped vesicle is thus formed which, as it grows, undergoes cell-divisions, and when such structures protrude from numerous pits, they fill up the cavity of the vessels and compress one another, and thus produce a parenchyma-like tissue."

* Sitzungsber., K. K. Akad. d. Wissensch, Vienna, 1867.

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TYLOSES.

It may be added in concluding this brief abstract of the opinions, already published, regarding **Tyloses**, that several writers have described the prevalence of this pathological condition in the fossil woods of the Eocene period, and one author is even supposed to have seen it in a non-gymnospermous fossil wood from the Lias.

95. ***Tyloses as a Serious Disease.***—Writers on the pathological state that has come to be known as **Tyloses** have spoken of it, however, as a remarkable condition that is known to occasionally occur or which may even be experimentally brought about. But it would appear that the Bengal plague in the betel-nut palms is the first record of this extraordinary suicidal degeneration having assumed the condition of a serious malady. It is usually affirmed that that condition is brought about during an abnormally rapid production of fundamental tissue. Excessive stimulation by water (at the roots of the plant), while the leaves are exposed to a very dry hot atmosphere, are the conditions supposed to be most favourable to the production of **Tyloses**.

It is customary to demonstrate this action by a glass tube having a few lateral holes cut through it. Within the tube a soft India-rubber bag, filled with water, is placed. So long as no pressure is exerted, the bag rests within the tube, but if pressure be communicated on the top and bottom, hernia-like prolongations emerge through the lateral perforations. The India-rubber bag is supposed to represent parenchymatous cells which, owing to an abnormal necessity, commence to grow and multiply. Finding least resistence by pushing through the pores of the pitted vessels they make their entrance and soon literally fill these vessels.

It may have been observed during perusal of paragraphs 74 to 87 and by contrasting these with paragraph 94, that there are certain points in my observations that seem to differ from the views hitherto published by writers on this subject. It may perhaps be helpful therefore if I exhibit some of these differences categorically:—

(*a*) I have never actually detected a nucleated cell in the act of passing through the pits of the vessels, that is to say, I have never been so fortunate as to detect a cell visible both inside and outside the vessel.

(*b*) In the early stages the nucleated cells may be seen as perfectly spherical in shape and appear, as it were, to ooze out of the substance of the walls of the vessels. (*Para. 75.*)

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AREGA Catechu.	Probable Nature of the Disease.

TYLOSES.

(*c*) They exist for a considerable time as perfectly transparent cells and neither seem to possess cell-contents nor a nucleus.

(*d*) As they enlarge and come into contact with each other they assume any and every shape, have very thin semi-transparent contents and a large nucleus with often also a distinct nucleolus. (*Para. 75.*)

(*e*) As already stated I have not been able to prove that these nucleated cells directly originate the subsequent pathological manifestations, but this much I think may be affirmed as certain, *viz.*, that the nucleated cells gradually disappear as the other conditions come into existence. (*Para. 74.*)

(*f*) The inner walls of the pitted vessels as also of all the other vessels of the xylem gradually become lined with a plasmic-like substance, at first pale-coloured, then yellow, next red and finally so dark red as to be almost black. A little later the vessels themselves are ruptured and torn to pieces. The plasmic substance is then seen to line the interior of the irregular longitudinal burrow thereby produced. (*Paras. 76-78.*)

(*g*) From the inner surface of this thick coating, short stout peduncles are produced that ultimately bear fairly large spherical cells. These are nearly transparent and do not possess a nucleus. By gemmation they in time give birth to chains of smaller and still smaller cells. (*Para. 80.*)

(*h*) The parenchymatous tissue immediately adjacent to such complete destruction of the xylem, as I have indicated, cannot be said to invariably nor even to any very special degree, manifest the destruction by **Tyloses** that might be anticipated.

(*i*) But the cells of the adjacent tissues have their contents discoloured, contracted and their nuclei have invariably disappeared. (*Para. 82.*)

(*j*) Turning now to the condition met with in the fundamental tissue. In no instance was I able to detect a hernia-like protuberance from the cell-wall, such as has been described in the **Tyloses** of Dicotyledons. (*Para. 94.*) In every instance the minute vesicles (or sporules as I have called them), that are formed in the parenchymatous tissue, were seen to originate from the contracted and discoloured cell

A. 1294-1328.

TYLOSES.

contents. They have their cell-walls complete before they rupture and pass through the mother cell-walls. (*Para. 82.*)

(*k*) It was occasionally observed that a sort of cell-division took place, the contents being split up into two, four or more almost spherical portions and that these became possessed of separate cell-walls before the mother-cell ruptured to allow of their escape. (*Para. 85.*)

(*l*) The discoloured cell contents seem to be identical both with the lining mentioned above, as seen within the vessels and with the plasmodial-like external substance mentioned (*Para. 84*) as found on the leaf-sheath.

96. ***Gumming of Sugar-canes by* Bacillus vascularum.**— While engaged reading the final proof of the above observations on the Betel-nut Plague, my attention was accidentally directed to **Dr. N. A. Cobb's** most interesting account of the disease of Sugar-cane, seen by him in the Lower Clarence River plantations of New South Wales. **Dr. Cobb** appears to have arrived at the conclusion that the diseased condition in question, and to which he assigned the name of "Gumming," was due to the agency of a **Bacillus** for which he proposed the name of **B. vascularum. Dr. Cobb** published in 1893 the facts known to him of that disease in a pamphlet entitled the "Diseases of the Sugar-cane" which was one of a series of papers designated, *Plant Diseases and their Remedies*, issued by the Department of Agriculture, Sydney. I have not been able to discover any further particulars, but doubtless much progress has been made in the study of that curious disease.

Dr. Cobb gives most instructive particulars as to the method he pursued in inoculating healthy canes with the **Bacillus**. He seems also to have been perfectly satisfied with the results obtained and has, therefore, no hesitation in regarding the diseased condition as due to the presence of **Bacillus vascularum.**

There is so much in common in the general symptoms and pathological lesions of the tissues concerned in the "gumming" of sugar-cane and the "plague" of the betel-nut palm, that I have thought it desirable to give here a brief notice of **Dr. Cobb's** investigations and to quote the pages in his pamphlet and paragraphs of this report (above) where closely analogous conditions have been denoted :—

1. When the sugar-cane is gummed badly the tops are seen to be dead. "The base of the arrow in such cases will be

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GUMMING OF SUGAR CANE.

found to be rotten, and usually one or more cavities of considerable size are to be seen near the top of the stalk, filled or partially filled, with offensive matter." (*Page 5.*) (*Compare with paras. 48-55 above.*)

2. If a stalk which has died at the top in the manner described, be cut into pieces with a sharp knife in such a manner as to leave the cut surface quite smooth, a honey-coloured gummy matter will, in a few minutes, be seen to ooze slowly out and form in droplets on the ends of the cut fibres. This gum is sometimes nearly transparent, sometimes rather opaque, and varies also in colour from nearly colourless into various tints of yellow according to the stage reached by the disease. (*Page 5.*) (*Compare this with paras. 77-78, 84-87.*)

3. "A microscopic examination of a thin slice across a gummed cane shows at once that the disease is not general but local. The gum, except in certain cases, is confined to the fibres; in fact, to the sap-vessels, the latter being plugged up with gum." "This confinement of the gum to the sap-vessels is one of the most striking microscopic features of gummed cane. In advanced cases, and in the more tender tissues at the top of the cane, the gum is not so local in its distribution; it may, under such circumstances, be found outside the fibres." (*Pages 8-9.*) (*Compare with paras. 74-79 also 94-95*).

4. Dr. Cobb found in the fresh "gum" a microbe which he recognised and figured as **Bacillus vascularum** (*pages 9-10*). I failed absolutely to prove that the **Bacterium** seen by me could be in any way whatsoever the cause but was in all probability only a consequence of the disease. Inoculation with the **Bacterium** on healthy betel-nut palms failed entirely to produce either the symptoms or the pathological lesions of the plague. (*Compare with para. 90.*)

5. Lastly, Dr. Cobb, while suspecting that the disease might be found to be more general than was known for certain, goes into some details regarding the climatic conditions, soil, etc., of the Lower Clarence River plantations (*pages 12-14*). "Gumming," he adds, "at present prevails on the farms

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RESEMBLANCE TO BETEL-PLAGUE.

below Maclean. Why is this? It is not, so far as I could observe, because of any inferiority in the cultivation down river. I believe that our question is answered by the fact that the land in the lower part contains more—that is, too much—moisture." (*Compare with paras. 90, 95, 98.*)

It may thus be admitted that the above and other circumstances that might be mentioned though striking and curious in no way prove that the two diseases are the same. I have accordingly ventured to draw attention to Dr. Cobb's most instructive paper mainly with a view to its becoming suggestive of lines of enquiry that might be dealt with in future manifestations of plague in the Betel-nut Palms of India.

Conclusions.

97. ***Conclusions.***—It will thus be seen that my observations coincide more with those attributed to Bohm than with the views advanced by the Baroness von Reichenbach, by Mohl, Reess, Sachs, etc. There seems a probability, however, that, with the exception of Mohl's brief remarks, the present is the only study of the form of Tyloses met with in palms, hitherto published. And it is significant that Mohl appears to be the only writer on this subject who has led special stress on the circumstance that in the course of development the Thyllen rupture the vessels. In the passage quoted above it will be seen that Mohl's words are that the Thyllen are produced by a "protruding expansion of the adjacent cell, which penetrates the pore and either tears through or causes the absorption of the primary membranes of the vessels." The plate which is given in the Journal of Botany in illustration of Sir William Thiselton-Dyer's paper shows both large cells within the vessels and smaller vesicles, but no description is given of the latter. According to my observations it is the minute vesicles that are the agents of final destruction.

Not only are the vessels of the xylem ruptured, but the so-called sporules or vesicles that appear in the fundamental tissue soon produce great caverns and rapidly effect the complete destruction of all the tissues. At this stage fermentative and other saprophytic organisms find a way into the young growing parts and in a few days the terminal bud and all the young leaves become reduced to an offensively smelling pulp and milky fluid. After the terminal bud has fallen to the ground the destruction extends down the stem

ARECA Catechu.

CONCLUSIONS.

Probable Nature of the Disease.

in the manner already described (*Para. 53*) so that in a marvellously short time what was a valuable property is converted into a forest of dead stems.

But there is a further point of difference between the published reports on **Tyloses** and my observations regarding the death of the betel-nut palms of Bengal. It has been stated (*Para. 95*) that **Tyloses** is supposed to be due to excessive stimulation by water (at the roots of the plant), while the leaves are exposed to a very dry hot atmosphere. In paragraph 93 I have shown that these conditions cannot be said to prevail during the period at which plague usually appears. The soil in fact becomes abnormally parched and if rain does not fall between November and May the atmosphere becomes excessively hot and dry. Rain usually falls, however, in January, and in normal years the danger of plague in the betel-nuts is thereby averted. We must look, therefore, to the deprivation of moisture from tissues that normally possess a large quantity of water for a possible explanation of the cause of the disease. The sprouting of the fundamental tissue and the production of nucleated cells into the xylem might easily enough be due to a pressing necessity for moisture in the young growing terminal bud. But in that case instead of the parenchymatous cells being in a state of extreme turgidity from which escape is attained by hernia-like developments into the vessels, it would seem that certain cells that exist in a state of greater vigour than others deprive the adjacent cells of their moisture and thus starting on independent lines of growth finally enter the xylem and absorb the crude ascending sap. Rapidly this process extends until the sprouting fundamental tissue produces what may be designated the false parenchymatous tissue, which has been seen to completely fill the vessels. In consequence of this interception to circulation the starvation and death of the terminal bud ensues and ultimately of the entire palm.

I advance this explanation, however, with considerable diffidence, since, as repeatedly stated, I have failed to establish several essential connecting links in the history of this remarkable disease. As explained (*Para. 88*) I was unable either by pure laboratory cultures or on young growing plants to communicate the disease to healthy tissues. From that circumstance I inferred that the so-called spores (*Para. 80*) and sporules (*Para. 82*) were in all probability not parasitic organisms.

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CONCLUSIONS.

But my failure to produce artificially the conditions necessary to originate the disease was most disappointing. I had several pots of betel-nut palms so placed that a liberal supply of water was kept at their roots while the leaves were exposed to the hot dry winds of March, April and May, but with no evil consequences. This seemed to indicate that excessive stimulation at the roots could not be the cause of the form of **Tyloses** seen in these palms. On the other hand, the atmospheric conditions in Calcutta during the past few years have not been such as to establish the disease in pots of palms that were rigorously deprived of water from November to May. I have thus not succeeded to induce the disease artificially, and it has apparently as mysteriously disappeared from Eastern Bengal as it had originally appeared. I have thus had no fresh opportunities since 1896 and 1897 of studying this purely constitutional disease, but there would seem no doubt that it is caused by a suicidal degeneration of the tissue very similar, if not identical, with that known in Europe under the name of **Tyloses.**

98. ***Remedy.***—So far as I can see there can be no specific cure for this disease. In other words neither fire nor insecticides (*Paras. 9 and 10*) can have any remedial effect. More careful cultivation with a system of drainage and irrigation that would remove excessive soil moisture or furnish water as needed, might very probably prevent its occurrence. So again there would seem every reason to believe that were the cultivators compelled to plant their betel-nut palms at such distances apart as to allow of interplanting with other trees the danger of outbreaks of plague might be greatly obviated. It will be recollected (*Para. 16*) that in the localities where *mandar* trees were left permanently on the circumference of the Betel-nut groves, liability to plague seemed greatly lessened. The presence of leguminous trees would tend to preserve the natural balance in the soil that can hardly help being seriously disturbed by a system of agriculture in which a forest of palms, planted every four to six feet apart, is allowed to occupy the soil for an indefinite period. Reforms in the system of cultivation pursued are, to my mind, the most hopeful methods of combating with the evil discussed in this paper. But in the country where betel-nuts are grown on a large scale and with the class of people who engage in that remarkable branch of agriculture preventative measures would very possibly be next to impossible, unless these could be made compulsory.

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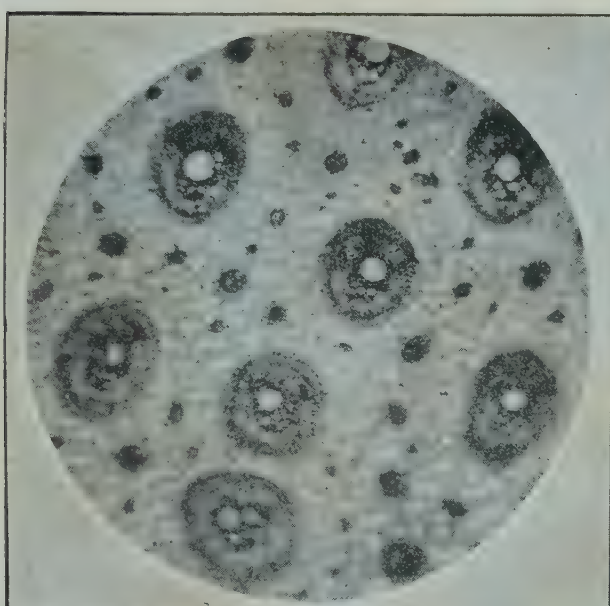
180

G. I. C. P. O.—No. 201 R. & A.—14-6-1901.—0,000.—C. M. W.

1

Transverse Section of a Fibro-vascular Bundle.
(Para. 59).

2

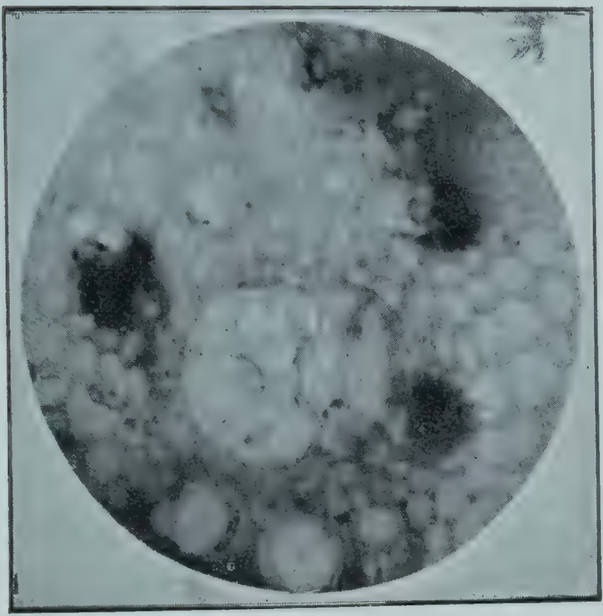


Transverse Section of Leaf Sheath near Middle.
(Para. 62).

3

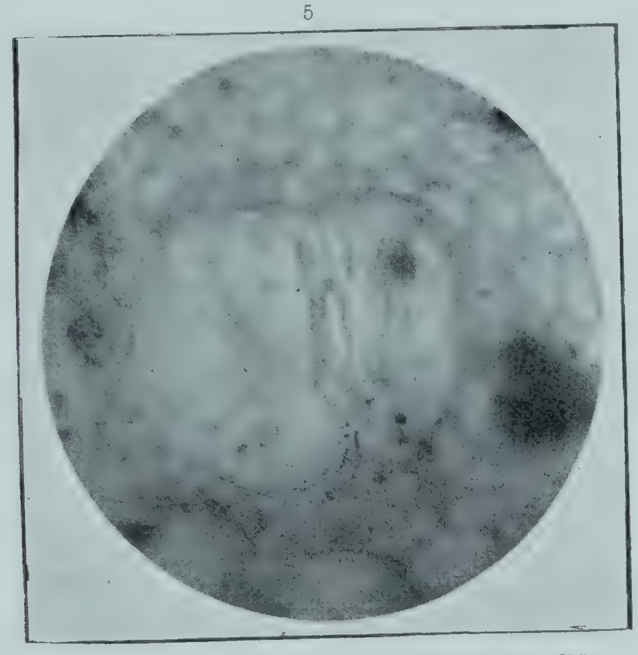
[illegible] Sheath near Margin.

4



Nucleated Cells within the Pitted Vessels × 450.
(Para. 74).

5



Nucleated Cells within the Pitted Vessels × 650.

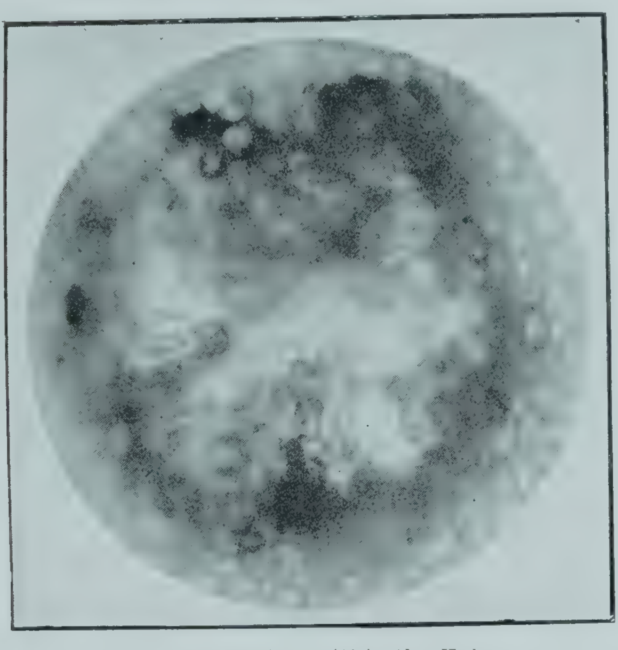
6

Transverse Section through the Stem.

7

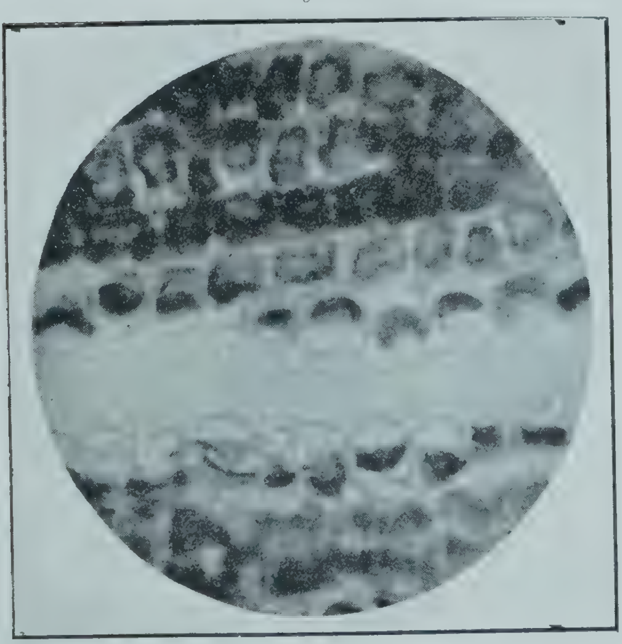
Xylem completely destroyed.
(Paras. 78 & 79).

8



Spore-like bodies within the Xylem.
(Para. 80).

9



Longitudinal Cavern filled with Vesicles.
([illegible])

(Entomological Series, No. 9.)

THE

AGRICULTURAL LEDGER.

1901—No. 9.

TACHARDIA (CARTERIA) LACCA, *Kerr.*

(SYN. COCCUS LACCA.)

[*Dictionary of Economic Products, Vol. II.*, **C. 1491-1511**, *also Vol. IV.* (*Lac*), **L. 1-18**.]

LAC (LAKH) AND THE LAC INDUSTRIES.

By GEORGE WATT, M.B., C.M., C.I.E., etc., *Reporter on Economic Products to the Government of India.*

INTRODUCTION.

INTRODUCTION.

The Economic Product that forms the subject of this paper is derived from several trees. It is a resinous incrustation on the twigs and is produced by a minute Hemipterous insect which belongs to the Family Coccidæ. It affords both a Resin and a Dye, the former being best known in the form of Sealing-wax, and the latter as Lake.

Historic Facts.

1. **Some Historic Facts.**—Of the minor industries of India few, if any, are so ancient as that of lac. The *palas* tree (**Butea frondosa**) is known to Sanskrit literature by the name of *Lákshá-táru* or Lac-tree—a designation that carries with it an antiquity of perhaps several thousand years and comes down intact to the present day. Throughout the length and breadth of India, in their varied languages and dialects, the aboriginal tribes recognise the *palas* as the Lac-tree. But so far as I have been able to discover lac finds no place in the literature of ancient Greece, Rome, Egypt, Persia or Arabia.

The resinous substance known to modern commerce as shell-lac (or shellac) was, if anything, more highly valued in ancient times in India than the dye, though it was the latter product which first found its way to Europe. And it was as a substitute for Cochineal that

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INTRODUCTION. Some Historic Facts.

Europe first sought lac. The rich crimsons of ancient Greece and Rome, were doubtless derived mainly from the parasitic incrustations of an allied insect met with on a species of oak (which grows abundantly) in the South of France, in Spain, Italy, the Greek Islands and Candia. The red particles picked off the branches of that oak, prior to the introduction of Cochineal from Mexico, were spoken of as "grains" or "berries" and hence fabrics dyed with them were termed "engrained;" and ultimately, owing to these crimson dyes being fast "engrained," became a general term in the dye trade for fast colours. The term *coccus* occurs both in ancient Greek and Roman literature. *Kermes* (*kirmij*), its Arabic synonym, means a little worm. From *kermes* we have derived, through Italian and French, the word Crimson. In Latin, *vermiculus* (a name often given to it) means a little worm and from that, through the French, we have derived Vermillion, while later on from Lac (or Lakh) we obtained Lake. Lakh means 100,000, a name given to this substance in allusion to the legion of small insects that are seen to swarm at certain seasons.

The old names of Lac Dye and Lac itself have given origin to terms denoting colour.

It will thus be observed that the contributions to the English language, traceable to this substance and its allies, have all a direct allusion to the dye, not the resin, which lac affords. But from very ancient times in India the resin has been, and in modern commerce is, by far its most valuable property. In the *Ain-i-Akbari* a work often spoken of as the Administration Report for 1590, issued by the Great Emperor Akbar we read of the proportions of lac resin to be employed in the varnishes to be used for the wood-work of public buildings.

The resin more valuable in India than the dye.

EARLY EUROPEAN WRITERS.

2. *Earliest European writers.*—One of the earliest European writers on the subject of lac was a Dutchman, sent to India on a scientific mission by the King of Portugal, *viz.*, **John Huyghen van Linschoten.** The report of his explorations was published in 1596, and the first English edition of it in 1598. He gives full particulars as to the uses of the resin, but curiously makes no mention of the lac dye. He shows however that he had arrived at an absolutely erroneous notion as to the agency by which the lac-incrustations were formed on trees. Since his interesting account of this product may not be readily accessible it may be here given :—

Linschoten, 1596 A. D.

Assi (? for Lac).

"Lacke" by the Malabares, Bengalers, and Decaniins, is called Assi, by the Moors Lac : the men of Pegu (where the best is found, and most

EARLY EUROPEAN WRITERS.

trafiqued withall) doe call it Treck, and deale much therewith by carrying it into the Island of Sumatra (in time past called Taprobana) and then they exchange it for Pepper, and from thence it is carried to the Redde Sea, to Persia and Arabia, whereupon the Arabians, Persians and Turks call it Lac Sumutri, that is Lac of Sumatra, because it is brought from thence into their countries. The manner how it is made is this : in Pegu, and those places from whence it commeth, there are certaine very great Pismyres with winges, which fly uppe into the trees, that are [there] like plum trees, and such [other trees] out of the which trees comes a certaine gumme, which the Pismires suck up, and then they make the Lac rounde about the branches of the trees, as Bees make Hony and Waxe, and when it is ful, the owners of the trees come and breaking off the branches lay them to drie, and being drie, the branches shrinke out and the Lac remayneth behind like a Reede, sometimes the woode breaketh within them, but the lesse woode it hath within it, the better it is : the peeces and crummes that fall upon the ground, they melt them together, but that is not so good, for it hath filth and earth within it : it happeneth oftentimes that they finde the Pismires winges within the raw Lac. When the Lac is raw, as it commeth from the Tree, it is a darke red colour, but being refined and cleansed, they make it of all colours of India."

"Thence they dresse their bedsteds withall, that is to say, in turning of the woode, they take a peece of Lac of what colour they will, and as they turne it when it commeth to his fashion they spread the Lac upon the whole peece of woode which presently, with the heat of the turning [melteth the waxe] so that it entreth into the crestes and cleaveth unto it, about the thicknesse of a man's naile : then they burnish it [over] with a broad straw or dry Rushes so [cunningly] that all the woode is covered withall, and it shineth like glasse, most pleasant to behold, and continueth as long as the woode being well looked unto : in this sort they cover all kinde of householde stuffe in India, as Bedsteddes, Chaires, stooles, etc., and all their turned wood worke which is wonderful common and much used throughout all India : the fayrest workemanshippe thereof commeth from China, as it may be seene, from all the things that come from thence, as Desks, Targets, Tables, Cubbordes, Boxes, and a thousand such like thinges, that are all covered and wrought with Lac of all colours and fashions so that it maketh men to wonder at the beautie and brightness of the colour, which is altogether Lac : They likewise use Lac to fill their Golde and Silver workes, that is to say, haftes of knives, and other things, which they make very fayre outwardly of Silver, and inwardly full of Lac. The Indians likewise are so cunning, that they make Ringes of Gold, which [to man's sight] seem [very] fayre and bright, as though they were all of massy Gold, inwardly they are hollow and stopt with Lac, and cannot be perceyved, unlesse a man bee advertised [thereof]. There is Lac likewise in Ballagatte and Malabar, but [very] little : the greatest quantitie which from thence is carryed throughout India, and all other places, commeth out of the Kingdome of Pegu."

It will thus be seen that **Linschoten** learned (300 years ago), very nearly every particular regarding the native use of lac, but from his

C. 1491-1511.

EARLY EUROPEAN WRITERS.

making no mention of lac-dye it may be inferred much less interest was given to that bye-product than was the case a hundred years or so later.

Letters to the East India Company.

3. Frequent incidental mention is made of gumlac and "Laqua" in *Letters Received by the East India Company*, edited by Mr. William Foster, as for example in Vol. III, which deals with the year 1615 A.D. There is, however, some reason to suspect that *Laqua* and *Lacree* may have had reference to a red wood rather than to lac. This at all events is the meaning put upon the term "Laka" by Crawford and he further tells us that it was a wood that came mainly from Sumatra though exported chiefly from China. Another interesting circumstance exists in the fact that the gumlac of these early records of the *East India Company* appears to have been derived (after Burma) mainly from the Western side of India.

Dr. Kerr, 1781 A. D.

After Linschoten, the next writer of importance, to whom attention need be directed, is Dr. Kerr, who first scientifically described the insect. His earliest paper appeared in the Philosophical Transactions, Vol. LXXI (1781), pages 374, *et seq.*, and plates 1 to 6. But in this connection mention may also be made of the following authors:—

Dr. Roxburgh, 1796 A. D.

Other authors.

Dr. Roxburgh [Asiatic Researches (1790), Vol. II, pages 360 to 366] who gave details of the life-history of the insect; Dr. Anderson, who wrote a Monograph on Cocci Ceriferi (1791); Dr. Pearson [Phil. Trans. (1794), page 383] who added further useful particulars; and Dr. Buchanan Hamilton who in his Journey through Mysore, etc. (1800), and again in his Statistical Account of Dinajpur (1809) was the first author to furnish an account of the methods of propagation and cultivation pursued in India. Coming down to more recent times the following names may be spoken of as intimately associated with the development of our knowledge of this subject:—Major Sleeman (1838); Dr. Forbes Royle (1840); Dr. H. J. Carter (1861); Mr. H. Baden-Powell (1872); Mr. J. McKee (1875); Mr. J. E. O'Conor (Note on Lac, 1876); Dr. U. C. Dutt (1880); A. F. G. Eliot James whose Indian Industries was published in 1880; Mr. L. Liotard (1881); Dr. H. M'Cann (1883); and J. Murray the writer by the article in the Dictionary of Economic Products (1889-90). Fuller details regarding these and other authors (who have contributed to our knowledge of this subject) will be found under the various chapters of this review to which their remarks more especially refer.

It may also be here explained that, in connection with the enquiry and investigations that have led to the publication of the present

MATERIALS FOR THE PRESENT ACCOUNT.

article, an extensive correspondence has been conducted. Direct local information together with an invaluable series of samples, in illustration of the details narrated, have been procured practically from every district in India where a trade in lac or an industry in lac manufactures exists. But as most of these exceedingly liberal correspondents have of necessity traversed the same ground, it was found impossible to publish more than a small proportion of the communications actually received. The others have been of the greatest possible value in maturing or confirming the facts here given. Where correspondents chanced to deal with methods or appliances not generally known, such portions have been stated under the names and addresses of the contributors.

Arrangement of the account.

It will be observed that the subject has been dealt with under certain chapters such as INTRODUCTION—A BRIEF HISTORY OF LAC AND LAC-DYE: INDIA'S EXTERNAL TRADE IN LAC: THE PRODUCTION AND CULTIVATION OF LAC: THE MANUFACTURE OF LAC AND LAC-DYE: THE CHEMISTRY OF LAC AND LAC-DYE: THE INDUSTRIAL AND ART USES OF LAC AND LAC-DYE. Within each of these chapters the effort has also been made to group information provincially. Commencing with Bengal and passing East and North, then turning West and South to Burma the provinces have been as far as possible taken up in the same sequence.

A special treatment was however found unavoidable for certain subjects such as the trees on which the Lac Insect feeds; the timbers used in Lac-turnery; and the pigments employed in colouring lac. These have been dealt with collectively and the information given on such subjects has (as far as possible) been removed from the letters that have been here published in other sections of this review.

CHAPTER I.

INDIA'S EXTERNAL TRADE IN LAC.

TRADE IN LAC, History of. 1792.

4. *Export Trade.*—It is surprising that it took half a century very nearly for the properties of the resin to be fully appreciated in Europe. Indeed from the crude methods of manufacture that prevail at the present day, one can hardly escape the impression that shellac is to some extent even still viewed as but a bye-product; it is hardly regarded as the article which alone finds a place in modern commerce.

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TRADE IN LAC.

Perhaps the earliest important reference to commercial transactions in this commodity is that which will be found in the Oriental Repertory, Vol. II, page 580, where Mr. Brown, Resident at Cossimbazar, wrote in 1792 that "If the Board shall think proper to send a few maunds of lac to Europe it can be procured in Calcutta." One of the earliest authentic records of the actual export trade in the substance will be found in H. H. Wilson's Review of the External Commerce of Bengal. That admirable report deals with the returns for 1813 to 1828. The following passage may be here given :—

Wilson, 1813 A. D.

"The export of lac-dye was long limited by the difficulty experienced in extracting the colouring matter, and applying it to manufacture at home. The high price of cochineal, however, stimulated ingenuity, and of late years the article has risen in demand. At first the value of the export was about two lakhs, from which it fell off to less than one lakh. In 1820-21 it again rose, and in 1824-25 its value exceeded seven lakhs, which elevation it has since maintained. Its use as a dye, however, depends upon the scarcity and dearness of cochineal, for which it is employed as a substitute; and so little temptation exists to embark in the manufacture of it, that it is rarely prepared, except according to contract. The resinous portion of the lac, known as shellac, has also increased in demand in England, being exported thither to the amount of nearly a lakh of rupees for some years past." (*Asiatic Journal, 1831, p. 220.*)

J. E. O'Conor's Returns.

5. At the beginning of the present century, therefore, the exports of lac-dye to foreign countries were some five or six times more valuable than those of the resin. Mr. J. E. O'Conor, C.I.E., Director General of Statistics, has furnished us with the figures of the modern foreign trade down to the present date. It may suffice to illustrate the tendency and character of these transactions if I quote here the returns for the past thirty years :—

Years.	Lac-dye.		Shell-lac.	
	Cwt.	R	Cwt.	R
1868-69	17,748	7,96,655	43,740	11,65,739
1869-70	20,864	9,26,072	54,548	12,75,401
1870-71	12,501	5,54,433	40,221	11,26,136
1871-72	17,463	7,81,189	57,820	16,18,942
1872-73	10,427	4,68,655	50,641	4,20,588
1873-74	9,907	4,45,612	65,790	18,41,491

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Years.	Lac-dye.		Shell-lac.	
	Cwt.	R	Cwt.	R
1874-75	8,385	3,76,340	67,701	18,95,281
1875-76	10,668	2,65,723	80,645	65,06,928
1876-77	19,051	3,78,556	89,880	42,20,497
1877-78	9,570	2,90,087	78,875	28,50,552
1878-79	8,261	1,95,285	64,498	22,24,843
1879-80	13,790	2,26,568	49,541	30,41,855
1880-81	6,304	1,30,201	60,842	43,16,267
1881-82	5,032	91,958	80,491	55,52,413
1882-83	3,927	46,104	102,871	55,47,619
1883-84	997	14,085	93,275	48,16,975
1884-85	106	1,274	106,747	45,36,326
1885-86	1,784	31,630	112,116	43,96,417
1886-87	915	16,188	115,137	40,16,127
1887-88	279	6,205	112,051	42,03,274
1888-89	334	8,038	81,390	31,94,125
1889-90	329	8,677	70,096	37,30,865
1890-91	163	5,018	112,496	59,48,599
1891-92	45	2,500	110,276	60,67,924
1892-93	249	10,090	102,079	64,38,513
1893-94	90	4,600	94,144	72,72,838
1894-95	402	26,025	131,367	1,14,76,706
1895-96	15	1,705	162,686	1,46,31,466
1896-97	*Nil.*	*Nil.*	175,728	1,19,35,957
1897-98	*Nil.*	36	189,329	92,86,795
1898-99	6	200	146,395	70,07,781
1899-1900	1	24	195,239	92,65,600

Striking Peculiarities.

I have not dealt with button-lac nor with the unmanufactured forms of stick-lac and seed-lac, because the quantities of these exported are comparatively insignificant (total in 1899-1900, button 40,320 cwt.; stick and seed 2,888 cwt.). The figures as they stand in the above table exhibit therefore in a remarkable degree certain striking peculiarities:—

(*a*) The decline and practical disappearance of the export trade in lac-dye from close on eight lakhs of rupees worth in 1868-69 to R24 in 1899-1900.

(*b*) The steady growth of the shellac trade from (at the beginning of the period) R11,65,739 to R1,46,31,466 in 1895-96 and R92,65,600 in 1899-1900.

(*c*) The remarkable fluctuations in the amount of the exports within the past 10 or 15 years.

(*d*) The erratic disturbances in the value of the commodity.

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TRADE IN LAC.

The following passage may be here given as manifesting some of the early historic features of the trade in Lac.

Imports and re-exports of Great Britain in the early part of last Century.

6. *Extract from the Asiatic Journal for July 1827, page 212.*

"Account of the Quantity of Lac-Lake, Lac Dye, and Cake Lac imported into Great Britain from the East Indies in the last Thirteen Years; also the Quantities re-exported, charged with Duty for Home Consumption during the same period.—(28th May 1827).

Years.	Imported.	Re-exported.	Paid duty.
	lbs.	lbs.	lbs.
1814	278,899	5,017	133,935
1815	598,592	8,441	137,915
1816	269,373	27,412	162,894
1817	384,909	23,091	234,763
1818	242,572	32,079	323,169
1819	179,511	21,707	207,063
1820	441,486	49,519	912,514
1821	641,755	91,925	322,837
1822	872,967	29,578	349,351
1823	534,220	13,050	414,714
1824	604,264	53,843	485,339
1825	541,443	61,908	385,734
1826	760,729	68,603	395,609

Countries importing lac from India.

7. *Countries to which exported.*—A further analysis of these returns reveals the fact that the United Kingdom has taken by far the major portion of the amounts.

In 1868-69, the United Kingdom took R8,82,020 and the United States of America secured R2,56,609 worth, out of the total R11,65,739. The corresponding figures for 1897-98 were, United Kingdom R40,22,914, and the United States R27,54,060 out of the total of R92,86,795; and from 1899-1900 they stood at R28,41,941 and R38,31,153 thus manifesting a great expansion in the demand from the United States of America. But a feature of the modern transactions which may perhaps to some extent be the result of the opening of the Suez Canal, *viz.*, the Continental supply that formerly used to go to London in the first instance, is now purchased by Calcutta agents and shipped direct to Continental ports. This difference in the course of the trade may be illustrated by the exports for the three following years:—

		Cwt.	R
1884-85	To United Kingdom	68,654	29,02,301
	To United States	21,152	9,53,644
	To Continental Ports	15,413	6,10,854
1897-98	To United Kingdom	82,291	40,22,914
	To United States	53,698	27,54,060
	To Continental Ports	51,069	23,97,907

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			Cwt.	R
1899-1900	To United Kingdom	.	60,257	28,41,941
	To United States	.	79,615	38,31,153
	To Continental Ports	.	52,102	24,24,255

Internal trade of India.

8. ***Calcutta Transactions.***—An examination of the Coastwise traffic reveals the fact that Burma and Madras send large supplies to Calcutta. The rail-borne returns similarly manifest the fact that the Central Provinces constitute one of the chief sources of the article exported from India *viâ* Calcutta. But Assam also sends a fairly constant supply to the metropolis. While every province in India possesses lac, the supplies are mostly used up locally, except in the case of the Central Provinces, Bengal, Assam and Burma, where there are available for the foreign traffic large surplus stocks over local demand. Calcutta is the chief emporium of the trade and India might almost be spoken of as enjoying a monopoly in the world's supply.

The World's consumption of Lac.

9. *Prices of Lac.*—The Secretary to the Bengal Chamber of Commerce, in a letter dated 11th June 1896, very kindly communicated the following interesting particulars:—"The world's consumption of lac between 1876 and 1895 has been approximately per annum:—

Orange	50,000 cases.
Garnet	12,500 ,,
Button	12,500 ,,
TOTAL .	75,000 ,,

Increase.

"In recent years there has been a slight increase in the consumption.

"The average for the past ten years is somewhat higher than that given above. Thus approximately:—

Orange	58,000 cases.
Garnet	13,500 ,,
Button	13,500 ,,
TOTAL .	85,000 ,,

Decline of trade in Lac-dye.

"A quarter of a century ago there was a large trade in lac-dye and the dye was more valuable than the shellac. Lac-dye is, however, to-day practically valueless having been superseded by Aniline-dyes which have flooded the market.

Price of Shellac.

10. "The following table will show the fluctuations in the price of shellac per maund during the last 20 years. The figures refer to

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Messrs. Angelo Bros. mark AC the price of which varies from R2 to R5 below that of a well-known standard mark TN; the table also shows the price per maund of lac-dye until it ceased to be an article of export from Calcutta:—

Prices Per maund of shellac and lac dye.

Year.	AC Garnet, lim'ts. R	a.	R	A. B. Lac-dye, limits. R	a.	R
1875 . .	55	0	70	25	0	
1876 . .	35	0		15	0	25
1877 . .	25	0		25	0	30
1878 . .	17	8				
1879 . .	21	0	65			
1880 . .	60	0	40	21	0	
1881 . .	40	0	30	2	4	
1882 . .	30	0		2	4	
1883 . .	25	0	30	0	8	
1884 . .	30	0	25	0	8	
1885 . .	25	0	20	No longer made.		
1886 . .	20	0				
1887 . .	17	0				
1888 . .	20	0				
1889 . .	20	0	30			
1890 . .	30	0	38			
1891 . .	30	0	40			
1892 . .	42	0				
1893 . .	40	0	50			
1894 . .	50	0	55			
1895 . .	55	0	60			

During 1896 shellac fluctuated between R40 and R60 per maund."

Demand in excess of exports; rise in price with reduction of stock on the market.

11. One of the largest shippers of Lac from Calcutta wrote in 1893 that:—"The annual foreign consumption is estimated approximately at 100,000 chests of two bazaar maunds each and the annual shipments from India fall somewhat below this. As a consequence, the stock in London and all over the world, has steadily decreased, and this decrease has been accompanied by a persistent rise both in rupee and sterling prices.

"The London stock and the London sterling price for the ordinary standard quality on the 31st December are shown by the following figures:—

	Stock.		Price per cwt.
1887 . . .	68,380	C . . .	58*s.*
1888 . . .	69,502	C . . .	56
1889 . . .	56,882	C . . .	75
1890 . . .	45,555	C . . .	72
1891 . . .	34,872	C . . .	93
1892 . . .	27,512	C . . .	95 6*d.*

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"The stocks in London at the close of last month were 25,681 C, and the London price 107*s.* per cwt. Of late years there has been a great rise in rupee values, but, owing to the extent to which these have been affected by the exchange fluctuations, we exclude them from this review.

12. "According to a contention put forward at home, shellac supplies are not increased, as a consequence of rising prices, which is commonly the case with other commodities, and this view is based on the belief that it is not profitable to propagate the **Lac insect** as a special industry, and that the crop of lac is simply the collection made by natives from unprotected and uncultivated trees.

"We need scarcely point out the importance to this country of preserving and extending this trade, which at present seems endangered by the rise of prices to a prohibitive level."

The above brief abstract of the trade in this commodity has been given here chiefly from its historic value as an introduction to a more detailed study of the production and manufacture of the various substances obtained from **Tachardia Lacca.** Further particulars regarding trade will be found in the pages below devoted to provincial production.

CHAPTER II.

THE LAC INSECT.

THE LAC INSECT.

13. Having in the foregoing remarks briefly indicated some of the more striking features of the growth of the present trade, it may be desirable to give briefly particulars regarding—1st, the Insect; 2nd, the Production and Supply of Lac; 3rd, the Manufacture of Lac and Lac-dye from the crude article; and 4th, the Industries in which lac is an important necessity (more especially Indian Art Industries).

Characteristics of its order.

As already stated, the Lac Insect belongs to the order **Hemiptera** and the Family **Coccidæ,** the Scale and Wax Insects. The majority of the members of that family are dangerous pests to crops and trees. They subsist upon vegetable sap which they suck up by means of a proboscis or tube which they insert into the succulent tissues of the host. In the adult state the females at least are fixed, that is, have no power of locomotion. Mr. E. E. Green, *Government Entomologist*, Ceylon, who is perhaps the greatest living authority on this family of insects, says that "There is scarcely a single cultivated

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plant that is not subject to the attacks of one or more species of Scale Insects, and some few plants seem particularly attractive to these pests. The common guava tree, for instance, is never free from 'bug.' On one small tree of this kind I have counted as many as seven distinct species at one time and such a tree growing in the midst of a field of tea or coffee will form a stronghold for such pests and a source of infection unless speedily eradicated." "As some little set-off," Mr. Green adds, "against the destructiveness of many of the Scale Insects, a few species may be quoted that are of economic use. The well-known Cochineal insect **(Coccos cacti)** producing the red colouring matter known as Cochineal is a case in point. Another species **(Tachardia lacca)** secretes a resinous substance from which is made 'lac' or 'shellac' of commerce, while from the insect itself is prepared the fine crimson pigment known as 'Lake.' **Ericerus pela,** a Chinese insect, secretes copiously a waxy matter that is used in the manufacture of candles in that country."

Two Species of Lac or more.

Conf. with pp. 217, 219.

14. Mr. Green further adds that there are two species of **Tachardia** that afford the lac of commerce, his remark having special reference to the forms of the insect met with in Ceylon. It is quite likely, therefore, that India may possess more than two species, and that this circumstance may account for certain discrepancies in the observations of Indian writers that have puzzled practical planters. Thus, for example, the remark that in Burma there are three broods or "evolutions," while in India generally there are only two, may be due to the fact of there being an additional species in that country. So again the fact that the lac insect found on the *palas* **(Butea frondosa)** and other soft wooded trees can with difficulty be made to live on the *Kusam* **(Schleichera trijuga)** may be due to the insect of the latter tree being a distinct species. It will be seen from Mr. Manson's account of the lac insect of the Sonthal Parganas (paragraph 82) that there is good reason to suppose that there are several distinct species of lac insect. But even if the paler coloured forms to which he alludes are but racial, and not specific, in value, a careful selection and development of a pale coloured race would result in vast improvements to the industry. The remarks made by Mr. Ryan in connection with the Banyan of Sind (paragraph 196) would seem to have a distinct bearing on the subject of the number of species of the lac insect. So again in a sample recently furnished by me to Mr. Green, the insect found was a new species of **Tachardia**: the

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twigs on which it was found were from **Ficus religiosa,** the Peepal tree and were contributed by Mr. E. H. Walsh, Collector of Monghyr. It thus very possibly follows that the differences in quality of the lac of different regions may thus have its origin entirely in the species reared. And what is even of more practical importance still, it may be found that with a careful study of the Indian forms certain of these may be less addicted to the destructive moth pest than others. But in these remarks I am to some extent of course only speculating though, it may be added, that I am justified in so doing from the fact that ignorance of the life-history of an insect and of the forms of that insect leaves a wide range of possibilities as affording the key to the explanation of widely different products.

Description of Larvæ.

15. *Description.*—Lac, as already stated, is a resinous incrustation found on the twigs of certain trees and is produced around the bodies of vast colonies of the lac insect **(Tachardia lacca).** When the larvæ escape from the mother they crawl about in search of a fresh sappy twig. They are then minute red or orange coloured insects, of an elliptical shape, obtuse anteriorly, attenuated posteriorly; about $\frac{1}{40}$th of an inch long; they are devoid of any recognisable separation between the head and the thorax; possess six legs, two antennæ and two small marginal eyes; and lastly have two very long hairs on the anal extremity that arise from the penultimate segment of the body. At this stage it is impossible to distinguish the sexes.

Swarming. *Conf. with p. 202.*

16. *Swarming Periods.*—They are generally seen to swarm at two and, according to some writers, three seasons a year, *viz.*, about the first week of July and again the first week of December or in some localities as late as January. At the periods named the twigs of trees infested with the lac insect will often be seen to assume a reddish colour, owing to the countless masses (lakhs) of minute larvæ that are moving all over them. The larvæ continue to emerge at intervals for about a month. This is a wise provision since had they all appeared at the same time they might have been destroyed by unfavourable climatic and other disturbances. The vast majority, however, die, either from inability to travel the necessary distance to find a fresh feeding ground, or from being incapable of puncturing the bark to obtain nourishment.

Emerge at intervals.

17. *Formation of the Resin.*—Those that become fixed, at once proceed, in the process of digestion, to transform the plant sap sucked up by the proboscis and to exude from their bodies the resinous

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matter with which they become ultimately incrusted. All the while structural changes are taking place and the larvæ are being gradually matured into the perfect insects. If at this stage a portion of the incrusted mass be broken through and examined it will be seen to be of a cellular structure, and that there are two shapes of cells, *viz.*, a large circular cell, and, secondly, a smaller ovoid cell. The former will, moreover, be found to be much more numerous than the latter and to contain the female insects.

Appearance of Males. Swarming of Males. *Conf. with p. 202.*

18. *Appearance of the Males.*—About $2\frac{1}{2}$ months after the periods of swarming, *e.g.*, about the middle of September for the first brood, and the middle of February to 1st March for the second, the male insects commence to escape from the ovoid cells already mentioned. At this stage they are about $\frac{1}{27}$th of an inch in size, and according to Dr. Carter have two pairs of eyes. The males of the first brood are wingless, but those of the second have one pair of long transparent wings. (Conf. with Roxburgh's observations, page 14, and Carter's, page 21.)

Reproduction.

19. *Reproduction.*—Upon the circular body of the female there are three openings which become developed as encrustation proceeds into three filamentous tubes. One is the anal aperture, the others are breathing stomata. The positions of these three apertures are indicated by the presence of a tuft of white powdery or hair-like filaments around each opening. Impregnation takes place through the anal aperture and the male insect then dies. Shortly after changes take place within the female. A central sac or ovary becomes greatly enlarged and charged with a bright red fluid. The

Formation of Eggs.

eggs then appear within it and each female bears, it has been estimated, as many as 1,000. As these near maturity the female dies. The larvæ are by some writers supposed to eat the red colouring matter and make their escape through the anal opening and ultimately through the completely ruptured body of the female. On this subject Mr. Green writes to me :—"It would perhaps be more correct to say that the larvæ are the colouring matter. It is the juices of the parent insect that go to form the huge brood and when these have escaped little is left of the parent but a dried and shrivelled skin."

The cycle is again repeated; and it will be noted that the incrustation formed by each brood contains no life after the emergence of the larvæ or young insects.

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THE INSECT. Practical Lessons.

20. *Practical Lessons.*—The practical lessons to be learned from this somewhat strange and complicated life-history may be briefly summarised:—

1st.—There are two broods, the swarming of larvæ taking place early in July and again early in December.

2nd.—It is commonly stated that the proper seasons to collect lac are, in May to June for the one, and October to November for the other crop, but it is believed these periods have been fixed with a view to preserve the dye as well as the lac.

3rd.—Up to the emergence of the larvæ the female insect is alive and is continuing the process of formation of lac. If the dye be of no consideration therefore, collection might be delayed until after the escape of the larvæ and the consequent death of the female. In the *Statistical Reporter* (*Vol. II, p. 406*) the statement occurs "Stick-lac gathered after the insect has emerged is known in Lohardugga district by the name of *phunki*. It yields scarcely any dye but is very good for working into shell-lac."

4th.—The seed-twigs intended for propagation should not be removed until immediately before the period of swarming. Should seed-twigs be cut off before maturity has been attained, the loss of the supply of sap in the twig would kill the mother insects and the brood be lost in consequence. The failures that have attended the attempts to send seed-twigs from one part of India to another have been due mainly to the fact that the seed-twigs were cut too long before the swarming period or too near it. In the latter case the larvæ would escape during transmission and finding no fresh twigs upon which to become attached would of necessity perish.

Method of Propagation.

5th.—The larvæ are so minute that the seed-twigs must be carefully attached to the plants upon which propagation is contemplated. A string tied across the twig will often suffice to check the swarming and the larvæ may be seen in thousands to have died in the vain effort to pass underneath the string. The best way is to impinge the seed-twigs across the bifurcations of the smaller branches of the tree.

6th.—The larvæ are so minute that they are doubtless carried from tree to tree by wind, by birds and by insects. The production of a winged generation of males is doubtless to complete the migration to other trees, effected by wind, birds and insects. It has been sometimes contended that the lac insect does not injure the trees.

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Apart from the improbability of that assertion, nature seems to provide for a migration and it appears, therefore, possible that the deterioration in quality often complained of, may be due to too long cultivation on the same trees. But in this connection I may add that the Collector of Monghyr recently sent me a few twigs of the peepal tree with lac incrustations on them accompanied with a statement that the older *peepal* trees of that district were all being killed by the lac. On page 192 reference has already been made to this instance and the statement made that instead of showing **Tachardia lacca** these twigs were found to possess a new species of **Tachardia** (*Conf. with Sir Jones' remark para. 25* (*p. 198*) regarding the *peepal* trees being killed by lac.

The above brief account of the lac insect practically tells all that is known regarding it. It may be of interest to many persons however to give here some of the more valuable and interesting descriptions of the insect and the formation of lac from the pens of the earlier writers :—

OLD ACCOUNTS OF THE LAC INSECT. Roxburgh, 1807 A.D.

Extract from the Asiatic Researches, Vol. II., 1789, pages 361 to 364.

"*On the Lacsha or Lac Insect.*

By Mr. William Roxburgh."

21. "Some pieces of very fresh-looking lac adhering to small branches of **Mimosa cinerea**, * were brought me from the mountains on the 20th of last month. I kept them carefully, and to-day, the 4th of December, fourteen days from the time they came from the hills, myriads of exceedingly minute animals were observed creeping about the lac and branches it adhered to, and more still issuing from small holes over the surface of the cells : other small and perforated excrescences were observed with a glass amongst the perforations, from which the minute insects issued, regularly two to each hole, and crowned with some very fine white hairs. When the hairs were rubbed off, two white spots appeared. The animals, when single, ran about pretty briskly ; but in general they were so numerous as to be crowded over one another. The body is oblong, tapering most towards the tail, below plain, above convex, with a double, or flat margin : laterally on the back part of the thorax are two small tubercles, which may be the eyes : the body behind the thorax is crossed with twelve rings ; legs six ; feelers (antennæ) half the length of the body, jointed, hairy, each ending in two hairs as long as the antennæ ; rump, a white point between two terminal hairs, which are as long as the body of the animal ; the mouth I could not see. On opening the cells the substance that they were formed of cannot be

Description of Insect.

* **Dichrostachys cinerea,** *Wight and Arn.*

OLD ACCOUNTS OF THE INSECT. Roxburgh.

better described, with respect to appearance, than by saying it is like the transparent amber that beads are made of: the external covering of the cells may be about half a line thick, is remarkably strong and able to resist injuries; the partitions are much thinner; the cells are in general irregular squares, pentagons, and hexagons, about an eighth of an inch in diameter, and ¼ deep; they have no communication with each other: all these I opened during the time the animals were issuing contained in one-half a small bag filled with a thick red jelly-like liquor, replete with what I take to be eggs; these bags, or utriculi, adhere to the bottom of the cells, and have each two necks, which pass through perforations in the external coat of the cells, forming the fore-mentioned excrescences, and ending in some very fine hairs. The other half of the cells have a distinct opening, and contain a white substance, like some few filaments of cotton rolled together, and numbers of the insects themselves ready to make their exit. Several of the same insects I observed to have drawn up their legs, and to lie flat; they did not move on being touched, nor did they show any signs of life with the greatest irritation.

22. "*December 5.*—The same minute hexapedes continue issuing from their cells in numbers; they are more lively, of a deepened red colour, and fewer of the motionless sort. To-day I saw the mouth; it is a flattened point, about the middle of the breast, which the little animal projects, on being compressed.

Males winged. Number present. *Conf. wit* *pp. 194 202.*

23. "*December 6.*—The male insects I have found to-day. A few of them are constantly running among the females most actively; as yet they are scarce more, I imagine, than one to 5,000 females, but twice their size. The head is obtuse; eyes black, very large; antennæ elevated, feathered, about two-thirds the length of the body; below the middle an articulation, such as those in the legs; colour between the eyes a beautiful shining green; neck very short; body oval, brown; abdomen oblong, the length of body and head; legs six; wings membranaceous, four, longer than the body, fixed to the sides of the thorax, narrow at their insertions growing broader for two-thirds of their length, then rounded; the anterior pair is twice the size of the posterior; a strong fibre runs along their anterior margins; they lie flat, like the wings of a common fly, when it walks or rests; no hairs from the rump; it springs most actively to a considerable distance on being touched; mouth in the under part of the head; maxillæ transverse. To-day the female insects continue issuing in great numbers, and move about as on the 4th.

The Ovary or Utriculus.

24. "*December 7.*—The small red insects still more numerous, and move about as before: winged insects, still very few, continue active. There have been fresh leaves and bits of the branches of both **Mimosa cinerea** and **corinda** * put into the wide-mouthed bottle with them: they walk over them indifferently without showing any preference, nor inclination to work, nor copulate. I opened a cell whence I thought the winged flies had come, and found several, eight or ten, more in it, struggling to shake off their incumbrances:

* This is most probably a typographical error, as there does not appear to have ever been a species known as **Mimosa corinda.**—G. W.

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OLD ACCOUNTS OF THE INSECT. Roxburgh.

they were in one of those utriculi mentioned on the 4th, which ends in two mouths, shut up with fine white hairs, but one of them was open for the exit of the flies; the other would no doubt have opened in due time: this utriculus I found now perfectly dry, and divided into cells by exceeding thin partitions. I imagine, before any of the flies made their escape, it might have contained about twenty. In these minute cells with the living flies, or whence they had made their escape, were small dry dark coloured compressed grains, which may be the dried excrements of the flies."

"Note by President."

25. "The Hindus have six names for Lac; but they generally call it *Lacsha,* from the multitude of small insects, who, as they believe, discharge it from their stomachs, and at length destroy the tree on which they form their colonies. A fine *Pippala* near Crishnanagar is now almost wholly destroyed by them."

It is curious that Sir William Jones should in the above passage have drawn attention to the fact that the lac insect was known to kill the *peepal* trees of Krishnagar. A recent correspondent has made the same observation regarding the *peepal* trees of Monghyr. (Conf. with paras. 20 and 66.)

Passages taken from the Journal of the Agricultural and Horticultural Society of India, Vol. XI., Part 11, July 1859 to December 1860, pages 37 to 45.

On the Natural History of the Lac-Insect (Coccus lacca). By H. J. Carter, Esq., F.R.S.

Carter, 1859 A.D.

26. "Having had an opportunity of examining the lac-insect just previous to the evolution of its young, and of watching the latter from this period up to the time at which they become incarcerated in the resinous substance which they secrete around themselves, known in commerce by the name of 'lac,' and finding that a description of the changes which the insect undergoes still remains unpublished, so far as I am aware, while that which has been stated on the subject is more or less incorrect, I am not without hope that the following observations may prove both new and acceptable.

"Thus much is known that the substance called 'lac' consists of a resinous incrustation partly encircling or scattered over the small branches of several trees and shrubs of different kinds in India; that the incrustation is cellular, and that each cell indicates the position of one of the insects which secreted it; that the insect contains a red colouring matter called 'lac-dye,' which is also an article of commerce, and is allied to cochineal; and that, at a certain period of the year, vast numbers of young animals leave these cells and, spreading themselves over the neighbouring branches, fix themselves to the

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bark, which they pierce with their beaks, and then begin to pour forth from their bodies the resinous substance above mentioned.

27. "On the 25th of June last (1860), my attention was drawn to the subject more particularly by a fresh branch of the Custard-apple tree (**Anona squamosa**), bearing portions of the lac, having been presented to me by my friend **Major Burke**. The branch was taken from a tree growing in the enclosure of the Bombay Mint, within a few yards of the sea, and in the midst of the smoke of steam engines, smelting furnaces, and the atmosphere of a crowded population; while the resinous incrustation and the red colouring matter, both in quality and quantity, did not appear to me to be less than that which is produced by the insect in localities widely separated as well from the sea as from all human habitations.

Female Insect.

28. *Female Insect.*—"On receiving this branch and observing that it was fresh, and that the insects in the incrustation were also living, my curiosity was directed to ascertaining the form and organology of the latter. Meanwhile the young began to pour forth—that is, on or about the 1st of July; and by the middle of that month the whole branch had become covered with them; but for want of nourishment, as they became stationary, so they died without apparently secreting any of the resinous substance around them; and thus I was obliged to visit the Custard-apple tree itself for the purpose of examining the subsequent changes which the insect undergoes,—which changes, together with a description of the form and organology of the full-grown insect, so far as I have been able to ascertain them, will now be related.

Escape of Larvæ.

"The first feature that strikes the eye on looking at the surface of the incrustation, when the insects which are within it are alive, is the presence of a kind of white powder, like that observed about the cochineal insects; this is concentrated here and there into little spots and on being more closely examined will be seen to be chiefly confined to three bunches of curly, hair-like filaments, which radiate from three small holes in each spot. The holes are situated triangularly with respect to each other, two being closer together than the third, which is the largest, and which, by and by, will be found to be the anal, while the other two will be found to be spiracular apertures: all three are continuous with corresponding apertures in the insect, from which the white filaments originally proceed, which filaments we shall hereafter observe to be the attenuated extremities of the tracheæ.

Anal and spiracular openings.

29. "If we now examine the contents of the interior, which we may easily obtain entire by dissolving off the lac in spirits of wine (for, from their tenderness, they can hardly ever be extricated without rupture by simply breaking the incrustation), it will be observed that each cell is filled with a single insect, which is now almost as much unlike one as any object can well be unlike another,—consisting of a pyriform sac of a dark-red colour, smooth, shining, and presenting at its elongated end one, and at its obtuse end three papillary processes; the former, which is a continuation of the elongated end, is fixed to the bark; and the three latter, which project from the middle

Lac may be dissolved off, and insect exposed.

CARTER'S ACCOUNT OF THE INSECT.

of the obtuse end are respectively continuous with the three holes, in the lac above noticed. As with these holes, so with the three processes; one is much larger and longer than the other two, which latter are of the same size; the former is also further distinguished by having several hairs round the margin of the aperture which exists at its extremity,—a point which it is desirable to remember, as it will serve, by and by, to identify it with the anal extremity of the animal when in its insect form.

Dissolution after death.

30. "So far the spirit of wine assists; but when we come to the contents of the body, it is not only necessary to avoid using spirit of wine, from the disfiguration which it occasions by causing the tissues to contract, but also to extricate the body by fracturing the lac, and dissect its contents as quickly as possible, on account of the rapidity with which they pass into dissolution after death; this is probably the reason why this part of the history of the insect has remained unpublished up to the present time.

The Ovary.

"Directing our attention to the interior, after the rupture of the insect, which takes place more or less with that of the lac, we are at once struck with the voluminousness of the organ containing the red-colouring matter, which organ thus obscures everything else; and it is not before a quantity of it is removed by gentle edulcoration that we can (still under water, for the anatomy of this insect can be studied in no other way) arrive at a view of the other organs of the body, when it will be observed that there is an alimentary canal, liver, tracheæ, and, last of all, the organ containing the red-colouring matter, which we shall presently find to be the ovary. To each of these organs, then, separately and briefly, we will now give our attention.

Alimentary Canal.

31. "The alimentary canal commences with an attenuated, shapeless œsophagus, at the elongated end of the body, which is thus seen to be the oval extremity, and after passing upwards for about two-thirds of the length of the abdominal cavity, where it becomes enlarged and convoluted, turns back to make a single revolution, in the course of which it soon becomes diminished in calibre, and receiving the hepatic duct at this point, terminates at length in the rectum, which opens at the great papillary process. The liver consists of a single straight, sacculated, beaded tube, of the same size throughout, presenting a yellow colour, and giving off the hepatic duct a little nearer, one end than the other; while the tracheæ are massed into bundles apparently without order, and send forth many of their extremities, through the two small, as well as through the large, anal apertures, to terminate on the surface of the lac in the way above mentioned.

Sexual organs.

32. "Lastly, we come to the ovary, which consists of a voluminous tree of tubes apparently branched dichotomously with each branch large and small, bearing long elliptical pouches, in each of which, again, is a correspondingly shaped ovum, the whole nearly filling the body and terminating in a single oviduct, which opens (probably through the rectum) at the anal apertures. The ovum, on the other hand, consists of an elliptical transparent envelope filled with little

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cells, each of which contains oil (?)—globules and globules filled with the red colouring matter. The oil globules are spherical, uniform in size, and much larger than the red globules, which are also spherical, but distinctly separated from the oil-globules and from each other. Whether these bodies respectively have delicate cell-walls or not, I am ignorant; but while they are both distinctly defined in the ovum when the insect is first opened under water, both soon burst by imbibition, and become lost to view by dispersion of their contents. Thus the red colouring matter exists originally in the form of distinct globules or in cells in the ovum. **CARTER'S ACCOUNT OF THE INSECT.**

33. "The further changes in the ovum, preparatory to the full development of embryo, I have not followed; but about the beginning of July the young ones are perfectly formed, and issuing through the anal aperture in the incrustation they creep on to the neighbouring parts of the branch, and soon fixing themselves by inserting their beaks into the bark as before stated, commence secreting the lac or resinous substance, in which they soon become incarcerated. Myriads issue in this way, as may well be conceived when, at a guess, I should think, each insect contained a thousand; but by far the greater number die; for although the branches become quite red with them, it is only here and there that a few, scattered or in groups, live; the rest still remain attached to the bark, but dried up and dead, which may arise, perhaps, from not having been sufficiently developed, or not being strong enough at their delivery to pierce the bark for sustenance. **Larva in July.** **One thousand to each female.**

34. "On leaving the parent, the young **Coccus** is of a minium red colour, about 1-40th of an inch long, elliptical, obtuse anteriorly, without any division between the head and body, possessing six legs, two antennæ, two small eyes, a marginal and lateral and two long hairs, growing from the penultimate segment of the abdomen; the body segmented regularly; the oral aperture ventral and placed at some distance from the anterior extremity; two tufts of white, powdery, hair-like filaments budding from the sides of the thorax respectively, in the place of wings, and a tuft of the same kind, bifurcated and curling outwards on each side, projecting from the anal orifice. Anal orifice surrounded by a row of short, strong hairs.

"At this period the insect is almost too small for examination organologically; but after it has crept off the incrustation and on to the bark of the branch, it soon becomes stationary, and enlarging, as the resinous secretion exudes from the surface of the body so as to surround all parts except the oral orifice and the three apertures from which the three white tufts issue, at the expiration of a month (that is, by the middle of August) it measures in length almost the 18th part of an inch. **Rapid Growth.**

35. "If we now examine it minutely, it will be observed that the legs, antennæ, and the whole of the chitinous parts of the body have become almost undistinguishably incorporated with the resinous secretion, which, when dissolved from the insect by spirits of wine, leaves the body almost in a larval or caterpillar form, but without eyes or any other appendages, save the three white tufts or **Becomes Fixed.**

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hair-like filaments and the proboscis, which is now fully developed. The proboscis consists of a fleshy projection, situated at a little distance from the head, ventrally, presenting a depression in the centre, from which issue four long hairs or setæ, based internally upon as many pyramidal inflations, situated almost at right angles to each other, and supported by other horny elements, which also appear to belong to the machinery of the proboscis. These hairs together form the penetrating organ through which the juice of the tree is extracted ; but whether they are hollow, and do this individually, or form a single tube by combination for this purpose, I have not been able to determine.

36." On the other hand, the three apertures from which the white tufts proceed, and which are now seen to open through the incrustation are observed to be situated in the thorax and at the tail respectively—thus identifying the latter, which will present the circle of hairs round the anal orifice, with the large papilla or anal orifice of the full-grown insect, and the former or thoracic apertures with the two other papillæ, which appear to replace the wings. The white tufts projecting from all these we have already found to consist of the extremities of the tracheæ covered with a white powder.

" Thus we see that the increase of size which takes place in the female insect, from its locomotive form to its ultimate development in the fixed state, is chiefly effected by an enlargement and elongation of the body between the mouth, on the one hand, and the parts from which the three white tufts project, on the other ; for the oral extremity simply becomes elongated, and the three other openings of the body remain as near together in the resinous incrustation, at the end as they were at the commencement.

" Of what the white powder on the tracheæ consists I am ignorant, further than that it does not dissolve in spirits of wine like the lac, which, on the other hand, appears to be a secretion from the skin generally analogous to the chitinous one which would be required under other circumstances."

Male Insect.

37. *Male Insect.*—" On the 8th of September I visited the Custard-apple tree again to see how the incrusted young were progressing ; and, on close examination of the parts where they were most congregated observed, here and there, little red insects actively crawling over them, which insects appeared so like original young ones, that I thought they must be a few stragglers of a later evolution ; but on inspecting them more particularly, they were observed to possess much larger antennæ : and therefore it was concluded that they were males, which afterwards proved to be the case. Several of them were collected for description, and a small portion of one of the branches, more or less covered by the incrusted young, brought away, to show how the secretion of the lac was progressing.

38. " The male is a little larger than the young ones at their exit from the parent ; it has larger antennæ, which are hairy-plumose and consist of seven articulations, not including the two basal ones ; four eyes, two lateral and two underneath the head ; two long hair-like appendages, covered with white powder, proceeding from the

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penultimate segment above; and a beak-like horny extension from the last segment, which is curved a little downwards and composed of two members, an upper and a lower one, both grooved, and forming together a cylindrical channel, through which the semen is conveyed into the female.

Production of males.

39. "Thus the changes which the larva undergoes during incarceration to produce the male, consists in an enlargement and alteration in form of the antennæ; in the differentiation of the head and the addition of two large eyes underneath it, which appear to be for the purpose of enabling the male, as he crawls over the lac covering the females, to find out the apertures in it that lead to the vulvæ; in the addition of the male organ, and in the replacing of the two hairs growing from the penultimate segment on either side of the tail by two delicate, white, twisted cords, composed of the attenuated extremities of the tracheæ. There are further differences between the sexes at this period, in the female having lost all traces of eyes, antennæ, and legs, while, no differentiation having taken place between the head and body, the female is reduced to a mere elliptical sac with but faint traces of the original segmentation. From the thorax, however, project the two tufts of white tracheæ which are absent in the male, and also a tuft from the anal extremity, the two hairs before alluded to having disappeared altogether; but the row of hairs round the anus, which are now absent in the male still remain in the female, and appear to serve the purpose chiefly of preventing the secretion of lac from covering up the anal aperture.

Characteristics.

Special adaptations.

40. "At this period only, the bodies of both male and female are about the same size (*viz.*, about 1-27th of an inch long); but while the former has become more highly developed and eliminated, for the performance of his special function, the latter has become retrograde and permanently incarcerated for hers. So unsparingly does Nature deal with her forms for the development of the new beings!

41. "*Impregnation.*—After having taken home the small portion of the branch above mentioned, which was covered more or less with the newly incrusted brood, on which there were no free males, I was astonished, on taking it up an hour or two afterwards, to observe that two had made their appearance, and were actively engaged in impregnating the females. This they do by drawing the organ before described downwards and a little forwards just over the hole in the lac which leads to the anal orifice of the female, and then inserting it; after which the male sits on the hole as it were, for a few moments, and then, withdrawing the penis, goes to another female, and so on till his office is fulfilled.

Males and Females on the Twigs.

42. "I now watched the process for some time; and having sufficiently satisfied myself of the fact as just stated, the two males were removed for microscopical examination, and the branch left as before without any. Next morning, to my astonishment, I again found two more males on it, actively engaged in performing their duty like the former ones; and then it struck me that they must come from some of the incrustations; so I examined the latter, and

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soon saw that there were two distinct kinds of incrustations on the bark,—one circular, slightly larger than the other, and, when *isolated* from the rest (which for the most part are agglomerated), presenting twelve notches or teeth symmetrically arranged round the base, six on each side, with the three holes above, and the white tufts projecting from them as before described; this, of course, was the female.

43. "The other form of incrustation was narrower and elliptical like that of the young insect at evolution, but without serrated base, holes or white hair-like appendages. Finally, it was observed that the latter were frequently empty, and open at their unfixed and elevated end, while from others the tail of the male insect itself was projecting.

Relative numbers. *Conf. with p. 202.*

"Thus the origin of the male and the process of impregnation as to time and act were easily determined; while it was also observed that in some parts there were almost, if not quite, as many male as female incrustations present, in others not so many.

Both sexes live on the twigs side by side for a time.

44. "On the evolution of the young, therefore, all at first would appear to attach themselves to the bark, and pierce it for nutriment —at least, all that live—preparatory to undergoing further general and generative development (for all are alike, apparently, when first hatched), and that then they respectively become changed for the fulfilment of their ultimate functions, the males for the impregnating the females, and the females for secreting the lac and developing the new brood; but the latter, as before shown, does not appear until the month of July of the following year. Thus we see that the young Coccus as we have termed it merits rather the term of 'larva' (from the metamorphosis which it subsequently undergoes to pass into the matured forms of male and female respectively) than that of 'young insect'.

Lac not an exudation from the tree.

45. "Again, all begin to secrete from their bodies the resinous substance even before they have fixed themselves to the bark; for those had it which are hatched from the lac on the branch that was first presented to me, after the latter was dry and dead; so that no doubt can exist of the lac being produced by the insect itself, and that it is not a mere exudation from the tree which follows the insertion of its proboscis into the bark, as has been stated.

"But while those which are to become males are entirely, though but temporarily, shut in by the lac which they subsequently elaborate from the juices of the tree on which they may be located, those which are to become females preserve throughout, the three apertures before mentioned, from which project the white tufts of tracheæ.

White tufts increased.

46. "These tufts, which previous to impregnation consisted of but a few filaments from each aperture, and thus in no way impeded the functions of the male, had so increased immediately after impregnation (that is, by the 20th of September), that every part of the branch covered with the new lac was rendered white by it; and although there were still a few females which were not enveloped by it (and probably, therefore, were not impregnated) yet for the

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most part they were thickly covered by this cottony substance; and the few remaining males that were present were so inextricably entangled in it, and so prevented from coming into contact with the females by it, that, together with the presence of dead ones also entangled in the mass, it may be inferred that this rapid evolution of the cotton-like substance at once indicates the death-season of the males, and that impregnation has been fully performed.

Collecting Season: May-June.

47. "One other observation I would add, which is more practical than scientific, *viz.*, that, to obtain as much resin and as much colouring matter as possible, the gathering of lac should take place towards the end of May or the beginning of June, just before the evolution of the young, which, as will have been seen above, carry away with them the greater part of the colouring matter. In Ure's 'Dictionary of Arts and Manufactures', which contains by far the best, and least incorrect, account of this insect that I have met with, it is stated that the evolution of the young takes place in 'November or December,' and afterwards, in 'October or November,' while the lac is gathered twice a year, in 'March and October.' It is also stated in the same article that the male insect has 'four wings,'* and that there is 'one to every 5,000 females,'* while we are not a little surprised to see, in P. Gervais and van Beneden's 'Zoologie Medicale' (1859), p. 374, that lac 'exudes from certain trees through the punctures which have been made by the females.'

Relative numbers of Males and Females.

48. "It was this and sundry other statements, together with seeing that the insect could be examined successfully only in the country where it lives, which induced me to avail myself of the opportunities presented to me of obtaining as much of its history as I could, for publication.

49. "On the 25th of *June* I received the branch of the Custard-apple tree with the living matured lac-insect on it in its incrustation. About the 5th of *July*, the young or larvæ, about $\frac{1}{40}$th of an inch long, began to issue. On the 14th of *August* all were fixed to, and progressively enlarging, in incrustation, on the Custard-apple tree. On the 8th of *September* the males were leaving their incrustations and impregnating the females each sex being now about $\frac{1}{27}$ inch long; and on the 20th of *September* the females were almost all concealed under an exuberant evolution of the white cottony substance (which we now know to be the attenuated extremities of the tracheæ covered with a white powder), with a single male insect here and there alive and many dead ones, entangled in it."

Bombay, October 11, 1860.

ENEMIES AND PESTS OF THE LAC INSECT.

ENEMIES OF THE LAC INSECT.

50. Very little of a definite kind is known regarding this subject. One of the most serious enemies, if one might say so, is the Native

* A statement originally made by Roxburgh, see page 197.

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cultivator himself. He is reckless and ruthless and through the greed of immediate gain very often materially interferes with the future supplies and at the same time only too frequently injures the host plant. Thefts are by no means infrequent and since lac is essentially a forest product great difficulty exists in guarding against such depredations. Hail also does considerable damage and unseasonal

Heavy Rain. *Conf. with pp. 46, 58.*

heavy rain often washes away countless colonies of larvæ. Forest fires are also exceedingly destructive to lac. Birds and monkeys are said to be enemies of a more or less serious nature and ants swarm on the lac trees in order to lick up the sweet excrement of the

Destruction by Ants. *Conf. below para. 52.*

insects. By some writers ants are viewed as by no means harmless visitants In the Indian Museum Notes (*Vol. IV., page 77*) mention is made of the destruction of lac by ants. The treatment recommended, *viz.*, to paint a ring of tar around the trees so as to prevent the ants ascending the stem, was found to kill the trees. It was next recommended to place dry sand on the ground around the stems of the trees with a view to prevent the ants getting at them.

Black Fungus not a parasite.

51. A black fungus in a like manner grows on the excrement of the lac insect and is often mistaken for a pest. It is, however, quite harmless, though it gives the trees on which lac is found an unsightly appearance. There are several species of parasitic fungi, which are found on scale insects allied to the lac, but so far as is known none of these have as yet assumed the condition of being blights on **Tachardia lacca.**

52. Mr J. McKee who wrote in 1875 an exceedingly interesting report on the Lac industry of the Central Provinces (see below paragraph 149) makes the following observations regarding the pests found on lac :—

How Ants are harmful.

"Besides the damage brought about by fires, drought and frost which to some extent can be guarded against, there are other enemies to the crop which are still more difficult to contend with. Mr. Thompson writes :—'The ant, both large and small, attends the female cell for the purpose of licking up the sweet excrement; they do not appear to hurt the insects beyond biting off the ends of the white filaments, and thus bringing many an occupant of the cells to a premature end by cutting off the supplies of breathing air which the filaments serve to convey through the holes in the lac. Where ants are seen about the lac it never appears healthy, and many cells are found with the insects dead inside them. The lac whilst on the

Moths Injurious.

tree is also attacked by the larva of a moth, which appears to be a species of **Galleria** belonging to the ninth section of the **Nocturnæ**

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named **Tineites** by **Latreille**, one of which is famous for eating into the honey-comb of bees, living on their larvæ and destroying their wax. Our insect eats the juicy females of the **Coccus** and bores through the lac cells; it is found both in the field and the store room. A second species was also detected which appears to belong to the genus **Tinea.**' The ravages of these insects destroy the colouring matter contained in the females, and also all hopes of a brood of young from the cells visited by them. At present there seems to be no way of protecting the lac from their depredations. The ants, however, may be circumvented, in two ways, either by surrounding the trees with wood ashes, or something sufficiently attractive to draw their attention away from the incrustations."

Moths attacking lac.

53. In December 1898 **Mr. F. F. Mackenzie**, Manager of the Rajpur Estate, Cachar, sent a sample of lac attacked by the caterpillar of a small white or grey moth. He asked for any method of destroying that insect which he said was doing serious injury. He remarked "these moths appear and lay their eggs in the immature lac on the trees and the larvæ on hatching out burrow through the cells and eat the red substance of the lac insects' bodies." "The moths," he added, "appear at all times of the year, evidently going through a number of 'cycles' like silk moths." The matter was referred to **Mr. E. E. Green**, Government Entomologist, Ceylon, but unfortunately he could not identify the insect since the sample contained "two larvæ and a small portion of a deformed moth." **Mr. Green** remarked, however, that the larvæ had the appearance of a Pyralid, but the small portion of the moth looked more like a Noctuid of the genus **Eublemma**—several of which feed upon **Coccidæ.** He added "I have reared **E. amabilis** from a species of lac insect in Ceylon and also several **Tineidæ.**"

Means of destroying such moths.

54. As to any method to get rid of the pest **Mr. Green** continued: "Without thoroughly knowing the local conditions, and in the absence of exact knowledge of the pest itself, it is extremely difficult to offer any recommendations. I can only suggest one or two lines of experiment. Your correspondent suggests the lighting of fires to attract the moths from the trees. A surer and probably more economical method of attracting them by light would be to set up in the trees small cocoanut-oil lamps each placed in the centre of a vessel containing kerosine and water. The light could be sheltered from the rain by a small piece of wood or tin fastened on to the tree above. The moths would be singed in the flame and fall into the kerosine and water surrounding the lamp.

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55. " During the monsoon, however, the wind would possibly extinguish the lights. At such times the use of small moth traps might be tried. A wooden box (such as a small tea chest) might be fitted on its open side with two sheets of glass sloping inwards, leaving a gap of about 1 inch, thus forming a funnel-like entrance to the box. A small lamp could then be placed inside the box, and behind it a sheet of tin to act as a reflector. Moths attracted by the light would find their way in through the gap between the two sheets of glass, but on account of the opposite slope of the glass they would be unable to find their way out again and in the morning could be easily killed. Such little traps could be placed at intervals through the plantation.

56. " Such means, however, though they might reduce the pest to a certain extent, would only give very partial relief. The insects could never be eradicated in this manner, and it is very difficult to conceive of any really radical treatment. The pest and its prey being both insects, it would be difficult to find any insecticide that would act on the one without the other.

57." I presume that the area of cultivation is too extensive, and the crop of insufficient value, to admit of the protection of the lac insects by means of muslin (or net) sleeves. It might be worthwhile to try binding soft grass loosely round some of the lac incrusted branches to see if it would keep out the moth. The experiment should be tried on the very young lac before the appearance of the caterpillar."

Eublemma amabilis one of the destructive moths.

58. In the *Indian Forester, Vol. XXVII., January 1901, pages 24-25*, a most interesting paper on **Eublemma amabilis,** one of the pests of lac, was published by Mr. D. O. Witt of the Forest Department. The specimens of lac from which this pest was subsequently reared had been collected in Damoh Division of the Central Provinces where they were found growing on **Zizyphus xylopyrus.** " I first noticed the attacks on the 26th September and collected some of the larvæ. The larva is white and unmarked, the head only being dark. It appears to feed upon the soft bodies of the lac larvæ, taking up its abode with them beneath their resinous coating and forming a webbed covering connected with the outer air by a silken tube woven together with an admixture of reddish excreta. Whether the tube is formed just previous to pupation, as a tunnel of escape for the perfect insect, I am not aware. Mr. G. C. Dudgeon, F.E.S. of Palampur, Punjab, to whom I am indebted for the naming of the insect and to whom I sent specimens of the larvæ, perfect insect and a specimen branch of the lac incrustation attacked by the larvæ of Eublemma amabilis, is of opinion that these silk tubes are made

ENEMIES OF THE LAC INSECT.

as a tunnel of escape, as the tubes are all of the same size and therefore presumably formed by larvæ in the same stage of development; and portions of the pupa shell were found inside the resinous coating just beneath these tubes. On the other hand, I did not notice that these tubes were ruptured by the emergence of the perfect insect.

59. "Six imagos of the larvæ which I collected early in November 1899, emerged between January 12th and 20th, 1900. Three more between January 22nd and 27th and two more on February 17th. It would appear therefore that one generation of the insect lasts about seven months, as the lac incrustation only begins to form in August."

60. "Mr. Dudgeon informs me that so far **E. amabilis** has only been recorded from Ceylon and Sikkim and now Damoh. It would appear therefore to have a wide distribution and it would be interesting to know whether it affects for instance the lac in Bengal and Assam. I also understand that it adds only the second species to the genus **Eublemma** now known to feed on a species of **Coccidæ**, the other described one being **E. coccidiphaga**, *Hamson*. It would thus appear that there is considerable room for investigation in this matter both with reference to **E. amabilis** itself and other members of the same genus. Among the more interesting points requiring investigation with regard to **E. amabilis** I may mention the following in the hopes that they may bring forth some information from other quarters:—

"1. Does **E. amabilis** attack both crops of lac? So far I have only found it on the winter crop.

"2. Does it attack lac on trees other than **Zizyphus xylopyrus**?

"3. How many generations of the insect are there a year? (There must surely be more than one because the interval between January when the imagos emerged, and August when the winter crop on which I found the larvæ commences to form, is unaccounted for.)

"4. The eggs, their form, colour, etc., and where are they deposited?

61. "Other points will suggest themselves to those interested in the matter, and I therefore need not add to the above.

"Owing to my being transferred to another district, I have been unable to continue my investigations on this interesting insect, but the above noted may lead to some one filling up the gaps I have mentioned."

62. A number of very admirable samples of stick lac having been presented in 1900 to the Indian Museum by Messrs. Carapiet & Co. of Mirzapore, these were arranged in a special show-case. Shortly after it was observed that two species of insects were escaping from the lac in addition to the males of the lac itself. One of these was a

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ENEMIES AND PESTS.

small yellow-brown moth which is as yet unidentified. This would appear to be the most destructive of all the pests of lac and to be very possibly the insect alluded to by the writers whose opinions have been briefly reviewed above. (*See paragraphs 52, et. seq.*) The second insect was also a species of moth but much smaller and of a very dark, almost black, colour. Unfortunately the material of this species was too imperfect to allow of determination. It may be added that the escape of the former from the incrustations of lac was carefully observed so that there can be no doubt that its larvæ feed on the lac. It may be further remarked that the moths continued to escape from the lac day by day over a period of at least two months and for a fortnight to three weeks after the appearance of the males of **Tachardia lacca** from the same sample.

63. These remarks regarding the pests of lac may, therefore, be usefully concluded by inviting attention to Mr. Ryan's interesting paper regarding the product in Sind (paragraph 196) where apparently it does not suffer from pests of any kind.

TREES FEEDING LAC.

TREES ON WHICH THE LAC INSECT IS REPORTED TO FEED.

64. The following may be given as a fairly complete list of all the trees and shrubs on which the Lac Insect has been reported to feed :—

1. **Acacia arabica,** *Willd.* (Leguminosæ). The *Babul* or *Kikar*. In Sind, Rajputana, and Guzerat yields large quantities of lac, is also said to do so in Berar and in the Punjab.
2. **Acacia Catechu,** *Willd.* (Leguminosæ). The *Khair.*
3. **Albizzia Lebbek,** *Benth.* (Leguminosæ). The *Sirin* of the Punjab and *Sirus* of Sind.
4. **A. lucida,** *Benth.* *Silkori*, Bengal.
5. **Aleurites moluccana,** *Willd.* (Euphorbiaceæ). The *Akrot* of the plains, introduced from Malay, now almost wild, especially in South India. It is mentioned as bearing lac in the Punjab.
6. **Anona squamosa,** *Linn.* (Anonanceæ). The *Ata*, a tree introduced from the West Indies; specially mentioned as affording lac in the Punjab.

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TREES WHICH FEED LAC.

7. **Butea frondosa**, *Roxb.* (Leguminosæ). The *Dhak* or *Palas* (Hind.), *Khankar* (Raj.), *Pankbin* (Burmese). Throughout Bengal, Berar, the Central Provinces, Rajputana, portions of the North-Western Provinces, South India, and Burma.
8. **B. superba**, *Roxb.* A climber, scarcely distinguishable from the tree **B. frondosa**, except by its habit. Lac found on it in Chutia Nagpur, the Central Provinces and Berar.
9. **Cajanus indicus**, *Spreng.* (Leguminosæ). The *Arhur dal.* Northern Bengal and Assam.
10. **Carissa Carandas**, *Linn.* (Apocynaceæ), var. *spinarum* (sp., A. DC). Yields lac in the Punjab.
11. **Celtis Roxburghii**, *Bedd.* (Urticaceæ). Punjab, Eastern Bengal, Central and South India.
12. **Ceratonia Siliqua**, *Linn.* (Leguminosæ). The Carob Tree; now almost naturalised in the Punjab and South India.
13. **Cordia Myxa**, *Linn.* (Boraginaceæ). The *Lasura* of the Punjab.
14. **Croton aromaticus**, *Linn.* (Euphorbiaceæ). Yields the medicinal lac of Ceylon.
15. **Dalbergia cultrata**, *Grah.* (Leguminosæ). The *Yindaik*, Burma.
16. **D. latifolia**, *Roxb.* The *Shisham* tree.
17. **D. paniculata**, *Roxb.* The *Dhobeyne*, mentioned in connection with the Central Provinces also Berar.
18. **D. Oliveri**, *Brandis.* The *Tamalan* of Burma.
19. **Dichrostachys cinerea**, *W. & A.* (Leguminosæ). The *Virtuli*, a shrub of Central and South India.
20. **Dolichandrone Rheedii**, *Seem.* (Bignoniaceæ). A small tree of Burma and the Andamans Islands.
21. **Eriolæna Hookeriana**, *W. & A.* (Sterculiaceæ). The *Butea* of the Central Provinces.
22. **Erythrina indica**, *Linn.* (Leguminosæ). Specially referred to in connection with the Punjab.
23. **Feronia Elephantum**, *Correa.* (Rutaceæ). Is reported to yield lac in the Punjab.
24. **Ficus altissima**, *Blume.* (Urticaceæ). The *Bar* of Assam.

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TREES WHICH FEED LAC.

25. **Ficus bengalensis,** *Linn.* The Banyan tree, *Barh, Bar-ghat* of the Central Provinces; *Bargad* of Rajputana; **is** also mentioned as a lac tree in Berar, the Puñjab and Sind.
26. **F. Carica,** *Linn.* The *Anjir* of the Punjab.
27. **F. comosa,** *Roxb.* The *Juri pakari* of Assam.
28. **F. Cunia,** *Ham.* The *Poro,* in Bengal and *Gular* in Punjab.
29. **F. elastica,** *Bl.* The India-rubber Tree (the *Bar*).
30. **F. glomerata,** *Roxb.* The *Guler* of the Central Provinces, *Gular* of Rajputana.
31. **F. infectoria,** *Willd.* The *Pakar* or *Keol.* Is very frequently mentioned as affording lac.
32. **F. laccifera,** *Roxb.* A native of Sylhet, the *Ruthal But.*
33. **F. palmata,** *Forsk.* The *Phagura* of Punjab.
34. **F. religiosa,** *Linn.* The *Aswat, Ahat* or *Pipal.* Most provinces: but lac very different as a rule from that on other trees being larger in grain and much paler coloured.
35. **F. Rumphii,** *Blume.* The *Jhuri* of Assam, an important lac yielding tree.
36. **F. Tjakela,** *Burm.* The *Pakhar* of the Central Provinces and *Pilkhan* of the Punjab.
37. **Garuga pinnata,** *Roxb.* (Burseraceæ). The *Garuga* or *Kaikar.*
38. **Grewia tiliæfolia,** *Vahl.* (Tiliaceæ). Berar.
39. **Kydia calycina,** *Roxb.* (Malvaceæ). A small tree, the *Pola* or *Barranga* in Bengal and the Central Provinces.
40. **Lagerstrœmia parviflora,** *Hook. f.* (Lythraceæ). The *Bakli, Lendya* or *Sida.*
41. **Mangifera indica,** *Linn.* (Anacardiaceæ). The Mango, in its wild state, often yields lac.
42. **Nephelium Litchi,** *Camb.* (Sapindaceæ). The Lichi.
43. **Ougeinia dalbergioides,** *Benth.* (Leguminosæ). The *Sandan* or *Tinsa,* mentioned in connection with the Central Provinces and Berar.
44. **Prosopis spicigera,** *Linn.* (Leguminosæ). The *Jhand* or *Kandi* of the arid zones of the Punjab, Sind and Guzerat.
45. **Pterocarpus Marsupium,** *Roxb.* (Leguminosæ). The *Kino* or *Bija* tree, a native of Central and South India.
46. **Pithecolobium dulce,** *Benth.* (Leguminosæ). The *Dakhini babul,* a tree introduced from Mexico.

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TREES WHICH FEED LAC.

47. **Schima crenata**, *Korth.* (Ternstrœmiaceæ). An evergreen tree of Burma.

48. **Schleichera trijuga**, *Willd.* (Sapinadaceæ). The *Kusam* or *Kusamb.* This is the most important of all the lac trees. It is a native of the sub-Himalaya, of Central and South India, and Burma.

49. **Shorea robusta**, *Gaertn.* (Dipterocarpaceæ). The *sal* tree. The ease with which this plant coppices, and its power of endurance and rapid growth make it one of the best trees for lac cultivation.

50. **S. Talura**, *Roxb.* A native of Mysore where it is known as *Jalari;* sometimes called **Vatica laccifera.** It is the lac tree of Mysore.

51. **Tamarix gallica**, *Linn.* (Tamaricaceæ). The Tamarisk of Sind.

52. **Tectona grandis**, *Linn.* (Verbenaceæ). The Teakwood or *Sagon*, a native of Central and South India and Burma.

53. **Terminalia tomentosa**, *W. & A.* (Combretaceæ). The *saj, piasal, asan.* Very abundant in Chutia Nagpur and the Central Provinces.

54. **Xylia dolabriformis**, *Benth.* (Leguminosæ).

55. **Zizyphus Jujuba**, *Lam.* (Rhamnaceæ). The *Ber, Bar,* or *Kul.* Although the lac yielded by this tree is inferior in quality, the ease with which it may be propagated makes it a good lac-yielding tree, suited especially to the Punjab, the North-Western Provinces, the Central Provinces, Berar, Central India, Rajputana and Sind. It is also referred to in connection with Assam where it is known as the *Bogori.*

56. **Z. xylopyrus**, *Willd.* The *Kat-ber* or *Ghonti*—specially mentioned in connection with the Central Provinces and Berar.

It is perhaps undesirable to refer more specially in this place to the above plants, since in the sections of the present review devoted to the chief areas of production, the trees of greatest repute in these will have to receive special consideration. The present may be regarded as an alphabetical enumeration which may serve as a key to the positions where fuller details regarding the chief food plants of lac will be found.

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INJURY TO THE TREES.

INJURY TO TREES.

65. Much difference of opinion prevails on the subject of the injury caused to the trees by the lac insect. It will be seen above (*paragraph 25*) that Sir William Jones alludes to the *Pipal* being frequently killed by the form of lac found on that tree. The following passage, from an interesting report by Mr. J. McKee, which has been placed under liberal quotation below (paragraph 149), deals with this subject :—

"It seems possible, owing to the great drain made on the sap of the young branches by the insects, that considerable damage will be found to result to the trees on which they are propagated, and that it will be necessary at some future time to fix a limit to the continuous cultivation of lac on the same tree; at any rate it will probably be found beneficial to both lac and tree, if a regular system of pruning be carried out to encourage the new formation of young twig or branch wood, and on the best methods of doing this, and on all other points in connection with the management of lac preserves we greatly hope that officers of the Department, who may have gained experience in this work in other countries, will convey all information available through the medium of *The Indian Forester*."

Passages taken from the Indian Forester, Volume XXII., pages 440-441, 1899.

NOTE ON THE INJURY DONE BY LAC TO TREES.

By* M. Ridley, Esq., *Superintendent of Horticultural Gardens, Lucknow, dated 6th June 1896.

66. "Regarding the statement commonly made, and as generally believed, that "if lac is not removed from trees it will in time destroy* the trees,' I have practically demonstrated and proved in the most conclusive way that the above theory is incorrect and entirely at variance with fact. When I first came here, 23 years ago, the matter then came under my notice, many large trees in the Wingfield Park, Residency Grounds, and the station avenues, were badly infested with lac, and the plan then in vogue was to sell the lac to contractors, who in collecting it denuded the trees to a most objectionable extent This led me to think of some way or means of keeping the trees clear of the pest. A Forest Officer informed me that this could be done by lopping off all the leading branches and afterwards stripping the branches and stems of all leaves and twigs,

* *Conf.* with Sir William Jones' statement on page 198 above.

INJURY TO TREES.

the object being to divest the trees of all the infected parts and to remove all trace of the lac insects and so prevent its breaking out on and spreading over the trees so treated again.

"I adopted this plan with one or two trees in the Wingfield Park, but found it ineffectual, as on the new branches and shoots which were developed, lac again appeared as badly as before. This plan proved an entire failure to protect or keep trees clear of lac.

"I then decided to stop lac collecting on a few trees to test and prove the theory about its destroying the trees. The result of this experiment was that after a time the lac all disappeared and the trees in a short period recovered from the effects of the lac and became perfectly clear and healthy again. This is absolute fact, and I can show numerous large *peepul* and *pakar* trees, which at one time were so infected with lac as to be most unslightly objects now entirely free from the pest, and the trees healthy and vigorous.

67. "On the representation I made to Mr. Boys, when Deputy Commissioner here, he passed an order prohibiting the sale of lac from trees in the station, and since then I believe no lac has been collected from trees in avenues and groves of Lucknow; certainly none has been collected from any of the gardens and other public grounds in my charge, and there has been no loss of trees in consequence.

68. "For some years there has not been much lac on trees in Lucknow, at least on those in my immediate observation; but whether this decrease of lac pest is due to collecting being prohibited or to the seasons not favouring its spread, I am not prepared to pronounce an opinion; but the fact remains that it has been much less in evidence for the past five or six years than it was for many preceding years.

"I have often been told that the lac gatherers inoculate trees to spread and propagate lac. The results here rather favour that statement. Prohibition may have shown them that they gain nothing by spreading it, and this may have led them to cease inoculating trees; but on this point conclusive and certain evidence is not forthcoming.

69. "I most decidedly do consider that trees are injured by the way lac is generally collected, owing to the removal of such a large portion of the young twiggy growth of the trees.

"Near, and in towns, the object of this free removal of twigs is two-fold: one to obtain as much lac as possible, the other to make money by selling the twigs for firewood. If proper and efficient supervision could be provided, lac might be removed to some extent by collecting dead twigs and a small proportion of the finer ones. The trees would not suffer to any appreciable degree if collecting was done in this way; but as the necessary supervision to ensure this is not available, prohibition is, in my opinion, the only safe method to follow.

"The theory mentioned at the beginning of this note comes no doubt from persons interested in lac, and is a purely selfish one.

"Others have accepted it from want of evidence to combat it, and so it has come to be generally accepted as fact. For this reason

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it would probably be useful to circulate the facts and experience given in this note."

70. It may be useful to conclude these observations regarding the injury done to the trees by the lac insect by inviting attention to Mr. Coldstream's remarks on lac production in the Punjab (paragraph 189). Mr. Ryan's observations regarding the lac-yielding trees of Sind (paragraph 196) may also be read in connection with the supposed injury to the trees.

CHAPTER III.

THE SUPPLY OF LAC, NATURAL PRODUCTION AND CULTIVATION.

DISTRIBUTION IN INDIA.

I have already indicated certain features of this subject. Lac is met with practically throughout the warm tropical areas of the whole of India, but most abundantly in the Central Provinces, Bengal, Assam and Burma.

71. *Relation to Environment.*—No satisfactory attempt has as yet been made to systematically investigate the relations of this insect to its environment. And yet there are indications in the scattered literature of the subject of many highly interesting discoveries that await the investigator. We have given us, for example, an extensive series of plants on which it may be found and even artificially reared. Of these we are told one tree yields in a certain locality the finest lac and in another only an inferior quality, or perhaps is never seen to bear the incrustations of this insect at all. In Sind and Guzerat, for example, the *babul* tree (Acacia arabica) may be said to be that on which it is met with most abundantly. In Bengal where both the *babul* tree and the lac insect are plentiful it is extremely rare to find lac on that tree. But is the *babul*-feeding lac-insect of Sind the same species as the *palas*-feeding insect of Bengal and the Central Provinces? Futile experiments have been made to convey the insect from Chutia Nagpur to Darjeeling while it seems probable success might have been secured had the seed been drawn from the moist warm temperate tracts of the Khasia and Garo Hills.

The same tree does not bear lac throughout India.

This may be due to there being more than one species of Lac-insect.

It is repeatedly stated that in the warm dry tracts the lac-insect is subject to none of the pests that beset the industry in the moister areas. So again, we read of lac appearing sporadically on the trees of certain limited areas and after a time gradually disappearing.

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72. I mention these examples, however, as but indicative of the extent of our ignorance. Few parasitic insects are wholly indifferent to the climatic conditions under which they live or to the nature of the food plants upon which they subsist. In the absence, therefore, of direct evidence to the contrary we are almost compelled from such considerations to infer that there may be several widely different species or, if not species, at least races of this insect. That these have been so acclimatised or adapted to their environments that they cannot be arbitrarily translated from one end of this vast empire to the other or forced suddenly to feed upon plants they have never before (under certain climatic conditions at least) chosen to subsist on. It is feared that in the present imperfect knowledge the wildest possible speculations have been indulged in and are likely to be repeated by persons who have advocated the establishment of an industry in Lac Cultivation. That the insect should be and is, regularly and successfully grown in several isolated localities all over India, goes without saying. That it is semi-domesticated over a still larger area is a well-known fact. But the mistakes that have been made in the effort to extend production have not alone proceeded from over-sanguine financial expectations. Failure has in many cases directly followed on ignorant misconceptions of the habits of the insect. It may, therefore, serve a useful purpose if I review here very briefly some of the facts that have been brought to light on the subject of cultivation or production.

RELATION TO ENVIRONMENT.

Special cultivation.

73. I shall endeavour, as far as possible, in the remarks that follow, to bring the information available under the names of the provinces concerned. Where quotations from authors are thought desirable these at the same time shall be given in historic sequence. I would, however, add that it may not be always possible or even desirable to avoid repetitions of the same particulars where the object may be to exhibit the extent of local knowledge or the particulars of trade.

Bengal.

74. One of the earliest writers on the lac trade of Bengal was Dr. Kerr. He published in 1781 an account of the production of lac on the *pipal*, the banian and the *palas*. He makes no mention, however, of any methods of cultivation or propagation. "The lac," he says, "is principally found upon the uncultivated mountains on both sides of the Ganges. The only trouble in procuring it is in

Production and Cultivation. Earliest Author Dr. Kerr in 1781.

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breaking down the branches, and carrying the sticks to market. The present price in Dacca is about 12 shillings the cwt., and it is brought from the distant country of Assam."

75. A good deal has been written recently about **Cajanus indicus** (the *arhar dal*) as a plant upon which lac is reared in Assam. This is by no means a new idea, as will be seen from the following passage:—

Asiatic Journal, 1825, page 50.—Rearing of the Lac Insect. Written in 1809.

Buchanan-Hamilton's account. 1809 A.D.

[*Being an extract from a Statistical Account of the Rangpur District by* Dr. F. Buchanan (*afterwards known as* Buchanan-Hamilton)].

76. "The rearing of the Lac insect is confined entirely to the east corner of the district, but it extends from thence all through Assam, and probably might be carried on in every high part of the district, or of Bengal; for the animal thrives on many common plants. In my account of Mysore I have given a description of the manner in which it was reared on the tree called "jala" which I suppose is a specimen of **sal** or **Shorea**. In this district it is reared on the following trees:—

Pakur	**Ficus infectoria.**
Dhop	**Varinga latifolia.***
Bot	**Ficus religiosa.**
Mejkuri	**Morus Macassariensis.†**
Mendu Kolai	**Cajanus indicus.**

"The first and last are the plants most commonly employed.

77. "The seeds of the "*mendu*" are sown in spring, generally in hedges round the garden. In the beginning of the cold season the insects are applied, by tying to each plant a small branch that contains them. In a year afterwards the small branches, then covered with the lac insect, are pruned, and in the year following this is repeated; after which the plant dies. In Bengal, where this plant is cultivated for the seed, it is generally an annual; but the pruning, which prevents it from running to seed, preserves its life for a longer period.

78. "The best lac is produced on the " pakur." Branches of this tree are planted in the rainy season, and in three years are of a size fit for receiving the insect, which is applied between the 15th of September and the 13th of November. In a year they have spread over all the small branches, and these are afterwards cut once or twice a year,

* This is no doubt a species of **Ficus** but the name *dhop* is not traceable to any species of the genus. It may have been **Ficus Cunia**.

† The plant referred to cannot for certain be identified: no species of **Morus** has been specially mentioned as a food-plant for lac.—*G. Watt.*

CULTIVATION IN BENGAL.

for about 25 years The trees are much stunted, but grow much larger than the "jala" on which the insect is reared in Mysore. A large tree will give two maunds ($84\frac{10}{16}$ sicca weight the seer), or about $173\frac{3}{4}$ lbs. The smallest give about $\frac{1}{16}$ of that quantity. The farmers who rear it usually exchange it for salt, and give two maunds of lac for one of salt. The salt there is retailed at about R8 a maund, so that the farmer has about R8 for $173\frac{3}{4}$ lbs., which is sometimes produced by one tree, with very little trouble. The quantity raised is very inconsiderable."

79. I shall now endeavour to bring together a few of the more instructive passages from recent published works or the files of correspondence in the Office of Reporter on Economic Products that seem likely to prove of interest in exemplification of the produc tion or cultivation of lac in the province of Bengal. As a rule, however, I shall take the liberty to remove all passages in suchquotations that repeat facts of universal acceptance.

Passages taken from the Statistical Reporter, Vol. II, pages 406-407, November 1876.

Lac Manufacture in Chota Nagpur.

Lac in Chota Nagpur in 1876.

80. "From the resin is manufactured the shell-lac, and from the colouring matter the lac-dye of commerce. The entire secretion, while still adhering to the twig, is called stick-lac. In order to obtain the largest quantity of both resin and colouring matter, the stick-lac should be gathered before the young come out. This occurs twice a year, in January and July; and the larvæ, as they emerge from the cells, carry away with them the greater part of the colouring matter. Stick-lac gathered after the insect has emerged is known in Lohardugga district by the name of *phunki*. It yields scarcely any dye, but is very good for working into shell-lac. If the manufacture of lac-dye were discontinued, *phunki* would come largely into use, and the seasons for gathering would in that case begin immediately after the insect had swarmed.

Phunki Lac.

81. "The present seasons for collecting lac are from the middle of October to January, and from the middle of May to July. Thick jungles are the favourite haunts of the lac insect, which is found in large numbers in the forest-clad tracts of the Chota Nagpur division and the eastern districts of the Central Provinces. Ranchi, therefore, is a convenient centre both for the collection of stick-lac and the manufacture of the commercial products known as shell-lac and lac-dye; and a factory has for some years been in working close to the cantonment of Dorunda, under the name of the Ranchi Lac Company. Large supplies of stick-lac are drawn from the district of Lohardugga, and from Raipore and Sambalpore of the Central Provinces, at prices paid ranging, according to the proportion of

CULTIVATION IN BENGAL. Two forms according to food plant.

refuse from R10 to R20 per maund for lac gathered from the *kúsúm* and R10 to R15 for that gathered from the *palás* per maund. Stick-lac from the *kúsúm* yields a shell-lac of a light yellow colour, which has the highest commercial value; while the raw material derived from the *palás* yields a deeper dye, but a less valuable shell-lac than the former."

Extract from the Indian Forester, Vol. VII, 1882, pages 274-279.

Lac in the Sonthal Parganas in 1881.

Note on the Lac Industry in the Sonthal Parganas (1881), by C. F. Manson, Esq., *Deputy Collector.*

82. "When the lac insect (Coccus lacca), or, as the natives call it, *lakor lakh*, was first introduced into this district is not known, but there is a concurrence of opinion that the Paharias were the introducers, or, at any rate, the first cultivators of it, and the industry is known to have existed in some parts of the district for the last 40 or 50 years. The insect is supposed to have been introduced from Manbhoom, but this must be only a surmise, since the date of its introduction is not even approximately known. Lac is a cellular resinous incrustation, secreted by the insect round the branches of various trees, having a colour varying from a deep orange to a dark red according to the tree on which it is produced. It contains from 60 per cent. to 70 per cent. of resinous lac, and 10 per cent. of a dark red colouring matter which is manufactured into lac-dye, the remaining 20 or 30 per cent. being refuse.

Variation according to food-plant.

83. "Lac, as turned out by the manufacturers, is termed *shell-lac*, known to the trade by various names, such as *orange-leaf*, manufactured principally at Mirzapur in the North-West; *reddish orange*, *livery leaf* and *button*, manufactured at Ilam Bazar in Beerbhoom, and by the Ranchee Lac Company at Ranchi in Chota Nagpur; and *garnet lac*, manufactured in Calcutta.

"Lac, as sold by the growers, is termed *stick-lac;* and as there are no manufactories in this district, it is with this raw material that we have to do.

84. "Lac is cultivated in all sub-divisions of this district, but most extensively in tuppah Handwai, in the sudder or Dumka Sub-division and which is nearly in the centre of the district. In this tuppah the original, and still the principal, seat of the industry is taluk Kesri, which alone yields the Zamindar a revenue of R2,000 a year from the lease of groves of trees for the cultivation of lac. Besides taluk Kesri, lac cultivation has long been known in the villages of Kainjor in taluk Nadia, Jartal in taluk Singui, and Ashanhani in taluk Baji, all within tne tuppah of Handwai.

85 "Haripur, the market town of Kesri, is still the chief business centre of this trade, although the industry has now spread to all parts of the sub-division. Its holding its own against the head-quarters town of Dumka is due, not only to its being the birth-place of the trade, and its still being in the centre of the chief producting area,

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but because the exports being chiefly made to Mirzapur through Baidyanath Station on the Chord Line of the East Indian Railway, it is a more convenient centre for accumulating stocks, being only 43 miles from the station, whereas Dumka would be 48. The other markets in the sub-division for lac are Kumrabad, about 5 miles south-east of Dumka, Sareyahat 28 miles north-west, and Nunihat 17 miles west-north-west of Dumka.

"Although lac has been produced here for the last fifty years, it is only within the last nine or ten years that the industry has developed into an important item of our export trade.

86. "I am not in a position to give accurate figures of the yield of the lac crops of past years; they might be compiled from the East Indian Railway records with some degree of accuracy, but the following statement of the principal traders' managers here, as reported by Mr. W. M. Smith, the Sub-Divisional Officer, shows sufficiently the extensive development that has taken place. He says:—'When I came here first, about eight or nine years ago, the annual crop was from 500 to 600 maunds. The last Bhadro crop (1880) yielded 16,000 maunds in the Dumka Sub-division, the Boishak crop (May 1881) about 6,000 to 7,000 maunds, and the present Bhadro crop (October 1881), which is not so good as last year's, is estimated at 10,000 maunds'. . . .

Expansion of Trade.

87. "The lac industry was no doubt stimulated in this district by the increasing demand that arose for the article in the London and United States markets in the years 1873, 1874 and 1875, the consumption of lac having been nearly doubled between 1870 and 1876. The price of lac was at its greatest height in 1873—74 since when it has declined again; the impetus given to the industry by the high prices having resulted in producing more lac than there was a demand for, the surplus stock in 1876 being more than a whole year's demand. This was partly caused by the manufacturers adulterating the lac with common American rosin in order to keep pace with the demand. Before the production of lac increased, this adulteration is said to have been carried on until it reached from 50 to 70 per cent. The fall in prices that took place after the increased demand had stimulated the production into overstocking the market is no doubt the cause of a falling-off in the cultivation reported from Godda and Pakour; but with a steady trade both production and consumption will increase, and already this year prices are again improving.

Food Trees.

88. "Throughout this district, with the exception of Pakour, lac has hitherto been cultivated only on the *palash* (**Butea frondosa**), Santali, *muru*. It is said, however, that it spreads itself to other trees in the neighbourhood of the *palash* groves.

89. In Pakour it is said that the cultivation is principally carried on on the native plum tree or *bair* (**Zizyphus Jujuba**), Santali, *jamun*.

"In the neighbouring district of Beerbhoom it appears to be principally cultivated on the *pipal* (**Ficus religiosa**), Santali, *hesa*, a common enough tree here, but the lac is of inferior quality to that

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produced on the *palash*, which is a more plentiful tree than the *pipal* and one of the characteristic trees of the Sonthal Parganas. It may be known to some as the 'flame tree' from its masses of bright reddish orange flowers.

"This tree appears to rise spontaneously from the ground, and is now being extensively preserved, so that the district is ready to meet almost any demand that could arise for the article.

"The best lac is, however, said to be that produced on the *kusum* (**Schleichera trijuga**), in Santali *baru*, on which it is, I believe, largely cultivated in Chota Nagpur. This tree is also common enough here, but I understand that the insect-producing lac upon it is not the same that we have here. Our insect varies between red and yellow, whereas the *kusum* insect, or, as it is called, *naguli*, is solely red.

Races of Lac Insect.

"The *kusum* crop of lac appears also to be later than that from *palash* or *bair*, being from middle of May to July, and middle of October to January; whereas the *palash* and *bair* crop is from middle of March to May, and middle of August to October. The lac from *palash* is only very little inferior to the *kusum* lac, and at the same time it produces the deepest dye.

90. "The seasons for setting and gathering the lac appear to be the same throughout the district.

Crops.

"There are two crops. the first in Cheyt and Bysakh, corresponding with middle of March to May; the second Bhadro to Assin, corresponding with middle of August to October. These crops, however, go by the name of Jeyth and Kartick, those being the months when the crop is in the local market.

"Lac is cut before the larvæ swarm, the colouring matter being a portion of the female insect's body. Most of the colour would be lost if the insects were allowed to leave the cell before cutting; some portion of the lac would also be lost by their breaking through the covering of the cell.

"The crop of Cheyt-Bysakh yields the most and best lac, whereas the crop of Bhadro-Assin contains a greater proportion of colouring matter.

Season of Setting.

91. "The manner of setting the insect for the next crop is simply to save a few well-covered twigs or a branch of the tree when cutting the crop, so that the new shoots thrown out by the tree being pruned down in the removal of the crop may be covered by the insect when it swarms, which for the Jeyth crop is in Kartick, and for the Kartick crop in Jeyth, corresponding with middle of October to November, and middle of May to June.

"To set the insect in a new grove of trees a branch of healthy lac containing the larvæ is tied in each tree.

Lac without larvæ.

92. "After the larvæ have swarmed the branches that were left or tied on the trees are cut and the lac sold, this lac goes by the name of *Plunki*.

"The mode of preparing the crop for the market is primitive in the extreme, and must result in considerable loss of material, especially of the colouring matter. Where the incrustation has

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formed on thick wood, it is scraped off with the reaping-hook or some other rough instrument; where it has formed on thin wood, the parts wholly covered are left intact; where it is only partially covered the uncovered portions of wood are roughly cut off, so that a large amount of wood or stick is sold with the lac, hence no doubt its name of 'stick-lac.' The cultivation of lac, as before stated, was formerly confined to the Paharias, with whom the zemindars made their own agreement as to rent to be paid for the trees. At the recent Sonthali settlement the rent per tree was fixed at two pice, that is, R3-2 per hundred; in many villages the groves of *palash* now contain several hundreds of trees.

93. "It may be said that all castes have now taken to producing lac of which the most numerous are Paharias, Sonthals, Bhuiyas, Khetoris, Goalas, Bauris, and a sub-division of the Kadar caste in Godda, called Leas. Several persons generally combine to work a lac garden, as watch has to be kept, lac thefts being not uncommon.

Profits of the Trade.

"The growers generally sell to the village mahajun or shop-keepers: sometimes taking advances on the crop; sometimes exchanging the produce for salt, tobacco and such like; and sometimes being paid in cash. Although the crop is no doubt a very paying one, the growers generally do not seem to improve their condition by it. To this there are some notable exceptions amongst the better castes. The growers are said to have obtained only R3 to R4 per maund for lac some few years ago. It then ran up suddenly to R27, R28, and even R30 near the railway; and then fell again to R12 and R13, and R8 and R9 per maund for last season's crop.

"The village shop-keepers who purchase from the grower, make a profit of from 10 to 20 per cent."

Extract from the Journal of the Agricultural and Horticultural Society of India, Volume VII., N.S., 1885, p. 262.

Hazaribagh District.

***The Lac Insect and how I propagated it at Burhee, in the District of Hazaribagh, by* Monsieur Claude Jean Dumaine.**

94. "Some years back, there was a small forest of *parras* trees **(Butea frondosa)**, which were being cut down for firewood.

"As a mere pastime, I thought of making use of them for propagating the Lac Insect, which proved successful.

"Having found at a short distance a tree covered with the said insect in the month of July, when the rains had well set in, I had large branches of this tree cut with a sharp instrument, so as not to disturb the living insect by hacking the tree.

"These branches were at once taken amongst the *parras* forest and subdivided in pieces varying from 6 to 8 inches long, which

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twigs were immediately tied to the tender branches on the windward side of each tree The natural result was that when these twigs dried up, the insects took at once to the adjoining branches and subsequently covered the trees.

"As a mere experiment, I tied some of these twigs on the opposite side of the tree, but this proved a failure, as no insect was found on it I naturally concluded that when the insects left the old twig, they were driven by the force of the wind to some adjoining arbor."

Passages taken from the Report of the Agriculture of the District of Lohardaga, by* Mr. B. C. Basu, *on the subject of Lac, pages 122-123, 1890.

Lohardaga District.

SHELL-LAC.

95. *Shell-lac.*—There are seven lac factories in Chota Nagpur proper—one at Ranchi belonging to an English firm, five at Bundu, and one at Arki in Tamar. The last six are owned and managed by natives of Sonamukhi, a town in Bankura. The breeding of the lac-worm and collection of stick-lac are a source of considerable profit to the people of the five parganas and the jungly parganas to the south, west and south-west of the sub-division. Almost every rayat of these parts has himself or hires a few *kúsúm* (Schleichera trijuga) and *palás* (Butea frondosa) trees on which he breeds the insect; some gather wild stick-lac in the jungles; others again act as middlemen. Besides, some five or six hundred workmen are engaged in the manufacture of shell-lac. The workmen of Bundu are one and all people from Sonamukhi, where they received their first training in the various processes of the manufacture.

96. "There are two different varieties of lac, *viz.*, (1) *rangin* or *palási*, grown on the *palas* and so called from its containing a large proportion of the lac-dye. Shell-lac made from *rangin* looks much darker than that from *kúsúmi*, which is translucent and of a beautiful golden yellow colour, and (2) *kúsúmi*, grown on the *kúsúm* above spoken of. Lac grown on *baer* (Zizyphus Jujuba) and *pipar* (Ficus religiosa), is classed with *kúsúmi*.

97. "The statistics of lac manufacture during the year 1887-88 are as follows:—

Number of factories	7
Number of persons employed (exclusive of the factory at Ranchi)	123
Capital of the six factories	R7,400
Outturn of the „ „	Mds. 2,226
Its value	R50,641

"The large lac factory of Ranchi did not supply any figures.

"The industry is in its decadence owing to the great fall in price of shell-lac and the extinction of the manufacture of lac-dye, which has been completely replaced by aniline dyes. The dye washings are now thrown away."

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Passage from letter No. 22 C., dated the 24th April 1894, from* Mr. G. D. Chatterjee, *Forest Ranger in Charge, Palamau Division.

98. "The selling price of the seed lac here varies from 1¼ to 1½ seers per rupee for *kúsúm* and 2½ to 3 seers for *palás* according to the yield of the seasons. The above rates are payable in jungle tracts situated within 30 to 40 miles from Daltongunj, so an additional expenditure of 2 (two) annas per rupee would be required to gather the seed lac at Daltongunj."

"The seeds of *palás* and *kúsúm* trees may be collected at Daltongunj at R2 per maund for the former species and 8 (eight) annas only for the latter. The time for collecting *palás* seed is from the middle of May to the middle of June and that for the *kúsúm* is July and August.

"If the above produce are required to carry up to Gya, the nearest Railway Station, it will further cost R6 (six) per maund when exported on a small scale by coolies and R2 (two) only when exported on a large scale by carts."

Passages from letter No. 110 C., dated the 21st August 1896, from* Babu Sreedhar Chuckerbutty, *Extra Assistant Conservator of Forests, Palamau Division.

99. "In 1895-96 the yield from 12 *kúsúm* trees in the Northern Range was 4 maunds 12 seers and from the seven in Southern Range 49 seers of lac.

"Among other interesting particulars the following may be mentioned :—

100. "***Explanation of terms used.***—*Morha* is the twig of the tree covered with lac. **Terms used in Palamau District.**

Dal is the lac which has become detached from the twig.

*Seed lac** is the morha from which the insect is crawling out and is tied into bundles and put on the branches of trees on which it is intended to propagate lac.

Sita is the empty seed lac after the insect left it. It is lighter than the seed lac and of a yellow colour, while seed lac is pink from the colour of the insect crawling on it.

101. "***Life-History.***—Rough life-history of the lac insect under cultivation :— **Life-History.**

"As the seed lac ripens an extremely minute pink larva emerges in myriads from the surface. It makes its appearance during the day, but goes back to the mother cell, which it shares with thousands of its kind during the night. At this stage the seed lac is cut from the original trees and bundles of it are tied all over a fresh tree, which it

* It will be seen that in trade "Seed-lac" has an entirely different meaning. *Conf. with* p. 277.—*G. Watt.*

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is proposed to bring under cultivation, as high up near the small twigs as possible. After a time the insect leaves the seed lac (which then becomes *Sita*) and crawls up the branches of the fresh trees and piercing the bark at some place sufficiently soft, fixes itself down and commences to secrete lac.

Dangers to Lac.

102. *Dangers to Lac.*—The lac insect at the time it leaves the protecting cover of the shell from which it emerges is most liable to injury as follows :—

Fire.

" *Fire*—A forest fire burning under and close to the tree on which the insect is crawling is likely to destroy a large number of insects, which being subjected to the intense heat and fumes of the burning, fall off the tree. It is also subjected to some danger by the intense heat of the sun.

Birds and Monkeys.

" *Birds and Monkeys* —Birds also eat the insects to some extent, though this does not materially affect the crop since the insects are so numerous.

" While the insect is actually growing and secreting lac, it is very moist and is at this stage liable to be damaged by monkeys, who eat the ' Morha ' and mischievously damage more than they eat.

Hailstorms.

Hailstorms.—" These do most damage in breaking off numbers of twigs destined to bear lac and also by shaking off the insects on to the ground. Hailstorms are most destructive to lac propagation, and wrought much damage to the crops in 1894-95.

Rain.

" *Rain.*—A severe downpour of rain, while the insect is still crawling, washes off a large number.

Frost and Cold.

" *Frost and Cold.*—As far as can be ascertained, frost does not appear to have any effect. This may be due to the insects returning within their mother cells at the approach of cold.

Theft.

" *Theft.*—Lac being a valuable substance here and at the same time portable, is very often liable to theft by the villagers."

Assam.

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103. At my request the Director of the Department of Land Records and Agriculture was good enough to cause a special enquiry to be instituted in the province regarding lac. As a result Mr. B. C. Basu, the Assistant Director, published in the Provincial Bulletin No. 6 full particulars. Since the present review of information would be incomplete without the province of Assam, I shall reproduce here some of the more instructive paragraphs from Mr. Basu's paper, even although the paper itself may be readily procurable :—

Production in Assam.

104. *Production of lac in Assam.*—Lac occurs in its natural state in various places in the forests of Assam, and is reared, more or less, in most districts of the province. Kamrup and the northern parts of the Khasi and the Garo Hills bordering on the Brahmaputra Valley, are at present the chief seats of its cultivation. In Kamrup, lac-rearing is chiefly confined to the south bank of the Brahmaputra ;

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the annual outturn of stick-lac in two mauzas (Rani and Chhayani) being estimated at about 2,000 maunds. A small quantity is reared by a few Kachari families in mauza Jhargaon on the north bank. The bulk of lac exported from the district is, however, obtained from Garos inhabiting the northern slopes of the Khasi Hills, who are said to annually bring in about 2,000 maunds of lac to the weekly markets at Palasbari and Chhaygaon and about 300 maunds to the market at Boko. A small quantity of lac, averaging about 400 maunds a year, is brought in by Bhutias to the annual cold-weather fairs at Darranga and Subankhata in the north of the district.

Localisation of lac-cultivation and Superstition against it in parts of the Garo Hills.

105. In the Garo Hills, lac-rearing is chiefly confined to the north and north-eastern parts of the district, comprised in the northern range of the Garo Hills Forest Division. The people of the south and south-western parts are said to have a superstition against lac cultivation. The annual exports of crude lac from the northern range is estimated at 1,300 to 1,400 maunds. In 1894, the Assistant Conservator of Forests, Garo Hills Division, estimated the annual production and export at 2,000 maunds, and reported a serious decline in the cultivation of lac, which he attributed partly to low prices and partly to the depopulation of the district through *kalá-ázár* and migration. Considering that the bulk of lac exported from the Brahmaputra Valley is the produce of the Kamrup and the Khasi and Jaintia Hills and the Garo Hills districts, and that the exports have during the past five years averaged over 16,000 maunds a year, the foregoing estimates of outturn of lac in those districts would seem to be much below the truth.

106. Very little lac is reared at the present time in any of the remaining districts of the province. None is produced in the sadr subdivision of Goalpara; in the Goalpara subdivision, about 200 maunds are said to be collected annually. It is said that some twenty years ago, several thousands of Ficus trees were planted at the foot of the Garo Hills in the Goalpara subdivision for the sake of lac cultivation, but the plantation was abandoned owing to the country having been subsequently devastated by *kalá-ázár*. In the North Cachar Hills, the annual yield is estimated at 100 maunds, and in the Sadr subdivision, Mr. Mackenzie, of the Rajpur estate, is reported to rear about 80 maunds annually. In Manipur, the annual collection is reported not to exceed 50 maunds in all, and the local produce is supplemented by imports from the Kubo Valley in Burma to meet the ordinary requirements of the people. It is not known how much lac is produced annually in the districts of Darrang, Sibsagar and Lakhimpur. The Deputy Commissioner of Darrang reports that the lac-rearing industry in his district was ruined some years ago by a blight which largely destroyed the insect. It is still reared to a small extent by Cacharis in the north of the Mangaldai subdivision. In Sibsagar, very little rearing is done now-a-days in the Jorhat and the sadr subdivisions. The small amount of lac required locally is obtained from the jungles. Some rearing is, however, done in the Golaghat subdivision. Lac-rearing is said to be unknown in Nowgong and the Naga Hills.

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Exports from Assam.

107. *Exports of lac from Assam.*—The following statement exhibits the exports of lac from each valley and the total exports from the province for the last fourteen years for which trade statistics are available :—

Year.	Surma Valley.	Brahmaputra Valley.	Total.
1	2	3	4
	Mds.	Mds.	Mds.
1885-86	177	29,916	30,093
1886-87 . . .	310	27,712	28,022
1887-88	132	27,450	27,582
1888-89	164	34,411	34,575
1889-90	240	15,190	15,430
1890-91	49	9,337	9,386
1891-92	...	14,753	14,753
1892-93	7	15,376	15,383
1893-94 . . .	130	6,017	6,147
1894-95	483	17,240	17,723
1895-96	183	15,732	15,915
1896-97	6,072	10,453	16,525
1897-98	29	24,840	24,869
1898-99	91	14,403	14,494

108. It will be seen that the Surma Valley contributes a very small proportion of the total exports. The trade reports furnish no explanation of the extraordinarily large and sudden increase in the exports of lac from the Surma Valley in 1896-97.

Upper Assam contributes an insignificant share of the total exports of lac from the Brahmaputra Valley. The bulk of the exports is shipped from the river ports in the Kamrup and Goalpara districts, and is the produce partly of these two districts and partly of the Garo and the Khasi and Jaintia Hills. A small portion of the exports is derived from Bhutan and Towang to the north of the Kamrup and Goalpara districts. The annual imports have averaged 374 maunds from Bhutan and 13 maunds from Towang during the past five years.

Decline in Exports.

109. There has been a marked decline in the exports of lac since 1889-90. The annual export from the Brahmaputra Valley, which had amounted to 30,000 maunds, more or less, for some years before 1889-90, fell in that year to about 15,000 maunds, which it has seldom exceeded since. It would seem that the causes which led to the decline of lac cultivation in the Garo Hills operated in a greater or less degree in every part of Lower Assam where lac is now reared.

With the exception of a few maunds of manufactured lac exported now and again, the entire quantity of lac exported from Assam is in the shape of stick or crude lac.

Method of rearing.

110. *Method of rearing lac.*—The method of propagating lac in Assam is practically the same as in Bengal. There are usually two

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crops of lac in the year, one being collected in May and June and the other in October and November. In Sylhet, the first is called the *Aus* or early crop, and the second the *Aman* or late crop. The first crop is mainly used for seed purposes; the second is the chief crop and supplies the bulk of the exportable article. A few days after the harvest, pieces of stick-lac, containing living insects (*rahilaha*), are tied on to the branches of the trees on which the next crop is to be grown. The usual plan is to place the stick-lac into small bamboo baskets and tie these on to the twigs of the trees. In a few days, the insects crawl out of the sticks, and spread over the young branches on which they at once begin to feed and secrete the resin. The secretion of lac is allowed to go on for about six months before it is gathered in. If sufficient lac has not been secreted, the insects are left undisturbed for another half-year. After the harvest, a fresh crop is immediately sown to be reaped six months later. It is said that a *Kathali bat* tree (**Ficus altissima**) can grow lac for three or four years in succession, after which it requires rest. Some trees have been known to produce lac for ten or twelve years without rest. A good-sized tree may yield from 30 seers to 2 maunds of stick-lac.

Exhaustion of Food Tree.

111. The lac insect does not thrive on *Ficus* trees which are of vigorous growth and contain an abundance of gum, but thrives best on trees of moderate vigour. The lac crop is liable to several kinds of pests, among which the most injurious are a species of ant, and the caterpillars of a tiny moth, both of which feed on and destroy the insect. The depredations of ants can be prevented to a certain extent by keeping the trunks of the trees clean, and by attracting the ants with jaggery and then destroying them with fire. Stormy weather at the time when the young insects are spreading over the tree may destroy them altogether.

Fig Trees of Moderate Vigour give most Lac.

112. Some additional particulars of interest bearing on the cultivation of lac have been received from Mr. Dicks.

113. Prior to receipt of the above special report the following particulars had been brought together in the files of correspondence and ledgers of the Office of Reporter on Economic Products. As these will be found to amplify in a few directions Mr. Basu's paper, they may be recorded here.

Passage from a letter received from the Assistant Conservator of Forests in the Garo Hills, Tura, 26th April 1894.

Lac in Assam in 1894.

114. "Lac is produced in the north and north-east parts of the Garo Hills. The Garos who live in the south and south-west of these hills never have gone in for lac cultivation, and I have recently learnt from Mr. Phillips (an American Missionary in the Garo Hills) that they have a prejudice against it. They allege that its cultivation defiles the ground and that evil spirits live in the shrubs and trees on which lac is found. As the Garos are a very

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superstitious people and many of the hill Garos very simple, it will be some time before they get rid of their scruples and fears.

Trees on which grown.

"The lac, which is cultivated in the north and north-east of the Garo Hills, is exported from Damra, Nibari, Jira, and Rongjuli *hats*, being brought to these markets by the cultivators who are for the most part Garos. The lac is cultivated on *Dal Arhar* and *Kapassuti*, 3 shrubs which the Garos plant scattered over their *jhum* cultivation. It is also found wild, but to no great extent, and is then met with on the *Pakri* (a species of **Ficus**) tree and on another tree called by the Garos *Boldaba*."

Former Prices.

"The local market for lac has improved during the last two years, the price realised per maund being R21. Previous to this, however, the market had been steadily falling, and the Garos found that lac cultivation did not repay them their trouble. They say that 8 or 10 years ago as much as R35 to R40 per maund was paid for lac in the local market, and that then the amounts exported were about ten times as much as now."

"I may add, though it is not in my district and may have already been reported to you by the Divisional Forest Officer, Goalpara, that in that district throughout the zemindari land at the foot of the Garo Hills there are many thousands of a **Ficus** tree which were planted 10, 15, or 20 years ago for the purpose of lac cultivation, but that now, owing to the country having been almost depopulated by the *Kalá ázár* disease no cultivation is going on."

Decline of Trade.

115. *Decline in Production.*—The Officiating Conservator of Forests in a letter, dated, Shillong, 21st February 1894, furnished the Inspector General with further additional information:—

"In reply," he wrote, "to your demi-official Circular No. 1 of the 3rd January on the subject of lac, and the possibility of extending the cultivation or collection of this product in the forests of Assam, I have the honour to inform you that the forests of this circle do not contain in any numbers, the species of trees required for the cultivation of the lac insect. **Butea frondosa**, so far as I am aware, is the only wild tree in the Assam Forests, on which the insect could be reared, and this species is not found here growing gregariously."

Other Crops may have Interfered with Lac Cultivation.

116. "The cultivation of Lac has been carried on exclusively by hill tribes—chiefly Garos, Mikirs and Miris, and it is believed that the falling off indicated by the table (see page 228) is owing to the fact that these people have found it more profitable to grow cotton than to cultivate lac."

State Production Impracticable.

117. *State Production Impracticable.*—"Under any circumstances the industry in Assam is not one that could be fostered by the Forest Department, because, as above stated, it would be necessary here to grow crops of *dal* for the production of the lac, and the employment of labour, that would be required to raise the said crops and to attend to the lac production and collection, would render the undertaking unprofitable or indeed impossible."

"The collection of a large revenue from this source in the Rewah State, was made practicable owing to three conditions, *viz.*:—

(1) Lac cultivation was made a State monopoly.

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(2) The trees required for yielding the best lac, namely, **Butea frondosa** and **Schleichera trijuga,** were very numerous in the local forests.

(3) Local wages are extremely low.

"None of these conditions obtain in Assam."

Dal a Popular Stock for Lac.

118. *Popularity of Dal as a Stock.*—In another communication, the Assistant Conservator of Forests, Garo Hills, reverts to the question of the popularity or otherwise of the crop. The following passages may be abstracted from his second report :—

"The cultivation is found exclusively in the north and north-east of the district and lac has never been cultivated in any other part of the hills. The people who have cultivated lac for some years like the cultivation; they say that on the whole it is more remunerative than cotton, and the work connected with it is very light, but they are not always successful, since some years almost their entire crop may be destroyed by ants, and I understand that there are other pests to which it is liable. The reasons advanced why many of the Garos have not cultivated lac are three-fold, as follows :—

Objections to lac cultivation put forward by Garos.

(1) *Superstition*: They say evil spirits dwell in the lac trees and shrubs and destroy their rice crops.

(2) *Injury to the Soil:* Their fear that their rice crops may be damaged since they say that (leaving aside evil spirits) the productive power of the soil is lessened when lac-producing shrubs are grown on it. They are unable to make two separate *jhums,* one for lac and one for rice, during the year, consequently they prefer growing cotton which can be raised between the first and second crops of rice without damaging the soil.

(3) *They are conservative:* They dislike making a change in the mode of getting their livelihood. Having been brought up to cultivate rice, or rice and cotton, and to look on lac as detrimental to the soil, they are too conservative to change."

These conservative sentiments may appear opposed to the fact of extensive emigration from the Garo Hills, having recently taken place, but that is not so since whole villages only left the hills because starvation stared them in the face. They were compelled to emigrate through the failure of their crops.

Middlemen.

119. *Middlemen in the Lac Trade.*—The Assistant Conservator further remarks :—In lac cultivation as with any other crop in which the cultivator does not deal directly with the manufacturer, the question of middlemen is the great difficulty. Before the lac reaches Calcutta it often passes through the hands of 3 or 4 middlemen, each of whom naturally makes what profit he can from the trade. Thus the cultivator sells to a Garo trader at the foot of the hills; it is next disposed of to a Bengali trader at the markets of Jira, Nibari, and Damra. who carts it to Goalpara; it is then purchased by a Goalpara merchant who ships it from thence to his agents in Calcutta, and finally it is brought into the market and sold to the manufacturers.

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Method of Propagation.

120. *Method of Propagation.*—The Director of Land Records and Agriculture, Assam, in a letter, dated Shillong, 7th March 1896, furnished the following particulars:—

"With reference to your letter No. 1526-36, dated the 13th November 1895, asking for a note on the propagation of the lac insect on the *arhar* plant (**Cajanus indicus**), I have the honour to state as follows:—

Fresh seed-lac is put into a bamboo *shora*, a kind of conical cage (somewhat like a soda-water bottle in shape) formed of strips of bamboo connected with thread, and hung upon the *arhar* plant during the months of October and November and again in June. The cage is hung on the plant on the day the moon is in conjunction (*i.e.*, the *Amabasya tithi*). After expiry of a fortnight (a longer time is required during the winter), the lac insects begin to emerge from the lac in the cages and repair to the boughs of the plants. Like the worms of the *munga* or *pat* silk, these lac insects do not spread over the whole tree; they occupy the same bough to which the cages are hung, and in order to spread them all over the tree, some 8-10 cages must be fastened to the boughs. When the lac is ready the cultivator lops off the branches and collects it. Lac put on the plants in October and November, is gathered in June, and that put on in June is gathered in November. The summer crop is superior in quality and quantity to the winter one, which may perhaps be due to the damage done by the cold fogs of December and January.

The proportion of seed to outturn is roughly 1 to 10.

The seed-lac cannot be kept for more than 3 or 4 days before putting it on a new plant. The seed should not be exposed to the heat of fire or the sun or to the natural heat which is generated when the lac is heaped up: heat drives the insects out of the cells and so kills them.

Possible Changes of Food-plant.

The lac reared on *arhar* plants can be put on to the other lac-rearing plants, such as (1) *Pakari* tree (**Ficus cordifolia**), (2) *Juri pakari* (**Ficus comosa**), (3) India-rubber (**Ficus elastica**), (4) *Ahat* (**Ficus religiosa**), (5) *Bogori* (**Zizyphus Jujuba**) and (6) *Bar* tree (**Ficus altissima**), but the lac grown on *arhar* is the best.

121. *Practical Experience.*—The following appeared in the *Indian Agricultural Gazette* of 1887, but the writer cannot vouch for its accuracy though it seems to express personal knowledge:—

Yield of lac from Cajanus indicus.

"The insect has no predilection for any particular shrub but experience has shown that the *arhar dal* shrub forms its most suitable habitat. If sown and well watered in November, the young plant will be fit to plant out at the close of the following rains—the end of October, and each should then be a good stout sapling, averaging four feet in height. When planted in rows four feet by eight apart about 1,360 will go to the acre, and if well cultivated will be found quite ready to receive the insect exactly two years from the date of first sowing. November is the time to get your stock lac, but arrangements should be made earlier in the season, say, August. The lac must be soft and pliable otherwise the insect will be dried

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up in the cells and useless, about half a maund or forty pounds will be found sufficient for one acre, and though the cost for fresh material may amount to a rupee a seer (2℔), it is well worth the expense, for, once stocked, you are independent; the best method of conveying the lac to the factory is in baskets well lined with fresh plantain leaves." "If the insect has been left undisturbed and the shade properly attended to, three years from the commencement of operations and one from the introduction of the insect, each tree will yield an average of 8℔ of lac, which, when freed from extraneous matters, such as twigs and leaves, and the dye washed out, will give 6℔ per bush of clean seed lac, the present price of which, in the London market, at £40 per cwt., gives £144 per acre less charges, such as initial cost, up-keep, freight, etc., but if care is taken to leave sufficient nucleus on the branches this sum may be looked for annually without the expense of re-stocking."

122. A writer in *The Planter* (November 1898) takes a less hopeful view of this subject. He says "**Cajanus** (the *arhar dal*) yields well and attains sufficient size in 12 months, but it requires to be re-sown every two or three years, does not stand drought well, and any damage to its roots, by hoeing or otherwise, causes it to die."

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123. One of the most interesting of the early writers on lac in these provinces may be said to have been **Major Sleeman** (*Trans. Agricultural and Horticultural Society, India, 1838, Volume VI., pages 47 to 51*). He was apparently the first writer who pointedly drew attention to the nature of cultivation of Lac as pursued with the trees. Speaking of a visit to the Mirzapore Lac factory he says:—"I was much surprised to find that none of the gentlemen who superintended it were aware of the fact that lac is as much *cultivated** as any other raw material for manufactory, that is, that the insect is *put* upon the trees upon which it is found to thrive best; and that the quality, and consequently, price in the market, varies with the kind of the tree from which it is taken."

Major Sleeman's Account.

124. "The lac is gathered twice a year, the best crop in April from seed applied to the trees in October; the second, which is inferior, in November from seed applied in June." "The people have sufficient seed for the next crop upon the trees from which they gather; and they do not consider the produce to deteriorate from the same seed being left long upon the same tree." "I have asked the people whether the trees require a fallow or not, and have told me that they

Seasons of Collection.

* The italics are Major Sleeman's.

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do not." The above passages have been specially quoted to show the views which Major Sleeman advanced on certain of the points already discussed. It seems probable that the Major's opinions have been unconditionally accepted by most writers during the past half century at least. "The Gonds tell me," he continues, "that though they cut twice a year they sow only once and that in October. During sixteen days of that month half the cultivator's family is employed in gathering the produce and the other in applying seed to fresh trees."

125. "The *Kusam* tree, on which the best lac is produced, has never yet, I am told, been cultivated, or, if I may use the term, domesticated; though it abounds in the forests of this part of India. The insects of the produce from this tree yields colouring matter superior to those of the produce from any other tree; but the great superiority of the produce from this tree over that from any other is in the matrix or gum in which the insects lie imbedded, as bees in their comb. This gum is of much finer quality for manufacture than that from any other tree; and what is of great importance to merchants and manufacturers, it will not only remain itself unimpaired in store-rooms for ten years, but retain the insects or colouring matter uninjured for that time, while the gum from the best of the other trees cannot be kept with safety for more than two years. The produce from the other trees is so very *brittle* that it is broken up and separated from the wood even the first season, before exported from the district in which it grows; but the produce from the *Kusam* is so firm and compact, that the comb or nidus could not be separated from the wood without destroying the insects or colouring matter; and the whole of the wood covered with the substance must be exported with it. A maund of this produce may sell in the market at the same rate as that from any other tree, merely because there may be a much greater portion of wood, which is of no value."

Storing does not injure Lac.

126. "There are immense groves of *dhak* trees, within a few miles from Jubbulpore, appropriated exclusively to the production of lac. In some cases the proprietor of the land cultivates the lac and sells it to the merchant exporter himself; while in others he lets his trees at so much a hundred to others who earn a livelihood by the cultivation."

Lac at Jubbulpore on Dhak Trees.

"The natives remark as a peculiarity which distinguishes the *Kusam* from every other tree, that every twig has six leaves, neither more nor less. It is certainly the case with the *Kusam*, but whether

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it is with any other tree I know not. I do not think it is with any other tree that I have seen."

127. "I think that in the produce from the *Kusam* tree, the gum. or nidus, bears a larger proportion to the insects, or colouring matter, than in that from any other tree; another reason why the raw produce from this tree may not fetch a higher rate of price in the market, though each of the two component parts is admitted to be of a quality so much superior; because the gum is an article of much less value, compared with its weight, than the insects."

The opinion that *Kusam* yields a larger quantity and a finer quality of lac than is obtained from any other tree has been affirmed by many writers. The circumstance that lac taken from the *Kusam* may be propagated on most other trees but that the reverse is rarely, if ever, successful, has been mentioned on more than one occasion, but neither of these statements can be said to have been definitely explained nor even sufficiently verified.

In the North-West Provinces Gazetteer, Vol. XIV (1884) page 213, the following interesting passage occurs:—

Cultivation about Mirzapur.

128. "The shell-lac manufacture was introduced early in the present century by Dr. Turnbull, a Surgeon in the East India Company's service, to whom also the erection of the first cotton-presses is due. In fact, this officer, whose name still survives in the river-side bazar of Turnbullganj, near Chunar, may be said to have been the father of the commercial prosperity of the city, as well as the architect of a considerable private fortune. The beginnings of the lac trade were aided by the then convenient situation of the city. The reputation made by the original manufactory, which, now owned by Messrs. Jardine, Skinner & Co., still commands the highest prices in the market, has enabled the industry to hold its ground against subsequent rivals, in spite of their superior advantages of position. A short account of the material and the process of manufacture may be subjoined. Stick-lac is found upon the *kusam* (Schleichera trijuga), *palas* (Butea frondosa), *ber* (Zizyphus Jujuba), *pipal* (Ficus religiosa), *bargad* (Ficus bengalensis), *gular* (Ficus glomerata), *pakar* (Ficus infectoria), and many other trees. The best is that obtained from the *kusam*. This is a light golden resin, known in the trade as *nagali*, and from it the most valuable orange shell-lac is made. The next best comes from the *palas* and is known as *baisakhi* or *katki* according to the month (Baisakh or Katik) in which it is gathered. It is darker in colour than the *nagali*, and the shell-lac is in consequence less clear and bright. These are almost the only varieties used by the

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European firms. The native factories, most of which turn out a very inferior article, utilize the produce of almost any tree on which the lac-insect is found. The best *nagali* comes from Sambalpur and Raipur, in the Central Provinces, and from the neighbourhood of Hazaribagh and Palamau, in Bengal. The latter places also give the best *baisakhi* and *katki*, but these varieties are to be found in many parts of the country.

The following letters from the files at my disposal may be given in this place as conveying useful particulars regarding the Lac production of the North-West Provinces and Oudh :—

Naini Tal

Copy of letter No. 611, dated the 21st February 1894, from the Conservator of Forests, Oudh Circle, North-West Provinces, Naini Tal, to the Inspector General of Forests.

129. "In reply to your demi-official Circular No. 1, dated 3rd January 1894, the success of lac-cultivation appears to be dependent financially on the presence of suitable species in large numbers in a limited area. In these Provinces the industry is worked by 'Manihars,' who take two crops a year from *Pipal*, *Dhak* and *Kusamb ;* the land-owners who possess such trees are careful not to allow them to be felled and foster the industry as much as possible ; this is especially the case in the Kapurthalla Estates which comprise the Ekowna forests.

Bahraich Experiment.

"Many years ago when in charge of the Bahraich Forest Division, I obtained a supply of seed from Kapurthalla and sowed it throughout the Motipur Reserves, but the attempt to increase revenue from this source proved abortive owing to the isolated nature of the species above named.

"In no important area in this Circle can this difficulty be surmounted, but I will direct all Divisional Officers to endeavour to spread the artificial culture of lac by offering the most favourable terms to the castes engaged in the propagation of this insect."

Cultivation at Dehra Dun.

Copy of letter No. 96, dated the 10th May 1894, from the Conservator of Forests, School Circle, North-West Provinces and Oudh, Dehra Dun, to the Inspector General of Forests.

130. "I have the honour to submit my report in reply to your demi-official Circular No. 1 of 3rd January 1894. That circular was sent to Divisional Officers in this Circle for report with the result that the Dun and Jaunsar Officers stated that they could obtain no information in their Divisions on the subject and could not find after enquiry that lac was grown. I think it likely that their statements are correct, both the Dun and Jaunsar being probably too cold for the insect.

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The Divisional Officer of Saharanpur, Mr. A. P. Grenfell, who has interested himself considerably in the subject, has reported as follows:— **CULTIVATION IN THE NORTH-WEST PROVINCES AND OUDH.**

131. "Lac is collected in small quantities near Roorkee and Pathri where there are numerous *Dhak* trees scattered about the cultivated land. The lac is cultivated to a certain extent by the villagers, but is not cultivated systematically and on a large scale. The produce is taken to Saharanpur, Roorkee, Jawalapur and Deoband, and is there sold to workers in various industries." **Saharanpur.**

"The lac sells from R8 to R10 per maund as it is collected from the tree; roughly cleaned lac unwashed but with sticks and stones picked out at R12 to R18 per maund. Seed-lac is not sold, as buyers take the uncleaned lac and clean it as they want it, but seed-lac of the same quality as the samples of lac prepared for analysis and sent to the Conservator of Forests with this office No. 299 of the 30th November 1893 would, according to Forest Ranger Pirbhu Lal, fetch R30 to R40 a maund in Roorkee and Jawalapur."

"The lac is used for making bangles and also (this probably refers to the dye) in tanning goat skins, also for varnishing turned wood articles, such as the legs of charpoys."

"There are no large dealers in lac and there is little trade beyond the borders of the district. If, however, the local supply is not equal to the demand, lac is imported from the eastwards and Riwari. Similarly, if there is a surplus of lac produced over local requirements it may be exported usually to the Panjab."

132. "It is noteworthy that the price of seed-lac is high, but most probably, if a large amount of seed-lac were placed on the local market, it would not find purchasers and the price would be considerably lowered. Pirbhu Lal, Forest Ranger, Central Range, reports that Saharanpur uses 25 to 30 maunds of lac yearly and probably the total supply and consumption of lac in the district does not exceed 200 maunds yearly, excluding the external trade which is inconsiderable." **Extent of Trade.**

"There is much land in Pathri forests suitable for cultivating lac, but it would be undesirable, I think, to do so on a large scale unless the lac could be profitably exported from the district and sold at a large market, such as Mirzapur. It would not do to trust entirely to the local demand to absorb a largely increased supply."

133. "In 1892-93 Mr. Grenfell collected a considerable amount of lac in the Saharanpur Division chiefly from *Dhak* trees at Ranipur near Hardwar. The stick-lac was washed and cleaned by the Forest Ranger and converted into seed-lac and samples of three qualities of this seed-lac were sent to the Reporter on Economic Products who first obtained from a native broker in Calcutta the information that the valuations were for the three samples, respectively, R30, R28 and R25 per maund. Mr. Thurston also submitted them to Messrs. Jardine, Skinner & Co., who sent them to Mirzapore and from thence received a letter from Mr. C. E. K. Skinner, dated January 2, 1893, as follows:— **Valuations.**

"Sample No. 1 appears to be seed-lac from fairly good new *Bysakee* stick-lac, but it has not been thoroughly washed, as there is

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still a good deal of the colouring matter remaining in the particles. I should be glad to have a maund and-a-half of this to convert into shell-lac when I would be in a position to put a price on it. No proper test can be made without making shell-lac from the above quantity. In any case, however, I would be prepared to give R25 a maund for it in the present state of the shell-lac market."

Bysakee and Katkee Lac.

"Nos. 2 and 3 appear to be from *Bysakee*, or mixed *Bysakee* and *Katkee* stick-lac. No. 2 seems to have been partly washed, No. 3 not. They both partake of the quality of one of our by-products, *viz.*, *Molumma*, and I cannot say whether they would fetch more than ten or twelve rupees as *Molumma* in the bazar here. They are what natives like for mixing with fairly good seed-lac for making the T. N. mark, and they might fetch the price mentioned for this purpose, but they are of no use to us for any of our present marks. I should imagine from their appearance that the stick-lac from which they were taken was either somewhat old or else partly blocked."

134. "The collection of lac in Saharanpur and its conversion from stick to seed-lac is an expensive work, small quantities costing as much as its value in the market. If there is a larger supply, it could probably be collected for from R10 to R15 per maund of stick-lac.

Lac Destroyed by Heavy Rains.

"Mr. A. P. Grenfell and Forest Ranger Puncham Singh made considerable attempts to 'cultivate' lac in Saharanpur, and in December 1892 and January 1893, I and the Forest School students were able to see several flourishing colonies on *Dhak* trees at Rampur. The experiment was to have been continued on a larger scale and we hoped before long to have a considerable amount 'planted,' but unfortunately the wet spring and hot weather and the heavy rains of 1893 had the result of killing off not merely our planted colonies, but also the lac insect in the forests, and this last year we have not been able to collect any at all. We have not even been able to get a few small quantities to place on the trees near the Rampur Range House, and if we are to continue cultivation we shall now have to obtain our 'seed' from elsewhere. I shall be glad of your advice as to the best place to get it from as I should like to try it again if only as an educational matter to show the Forest School students how lac is produced and collected and used. I am afraid that even the Saharanpur Division is too cold and at some seasons and in some years too wet for it to be worthwhile to grow lac on a large scale, and that consequently little can be done in this Circle to encourage trade in it beyond growing it experimentally so as to teach students and others what the process is, and that it is really very easy in suitable place and climates."

Statement by* Harsukh *and* Ghanesha Khatik *of Jawalapur District, Saharanpur, who grow lac in the village forests of Alipur, Chandpur and Burhampur, etc., near Jawalapur, dated 25th November 1896.

135. "The seasons for propagating lac seed are October and July, the latter being more favourable. The twigs with old crude lac are

tied on the branches of fresh *Dhak* trees **(Butea frondosa)**. From four to eight twigs are tied on each tree according to its size and foliage. The seed then spreads on all the branches and twigs in about a month, and it is often carried to other trees by the help of the wind. The twigs with lac seed should be tied up while green, for if they dry up the lac, insect would die and become inactive." CULTIVATION IN THE NORTH-WEST PROVINCES AND OUDH.

"Lac seed put out in October yields crude lac in June, and that put out in July yields in October. The twigs are cut down and twisted with the hand by which means the crude lac is at once separated. This crude lac is then sold either as it is, or compressed into a compact mass by putting it out in the sun in a basket lined with leaves and by pressing it down when softened."

136. "Shawl merchants from the Panjab often purchase the crude lac for colouring woollen and other cloths, and it is also used by tanners for imparting colour to hides. Other uses are not known here. The local selling rate varies from R10 to R40 per maund in different years according to production and demand." Lac Dye for Wool.

"For preparing refined lac for varnish and sealing, etc., the crude lac is washed several times in water, and fine shining grains are obtained, which are then melted and formed in various shapes. This lac sells at R40 to R100 per maund. The refined lac is not, however, prepared locally as a rule."

137. "The production of crude lac per tree varies from 2 to 20 seers, according to the size and foliage of the tree and to the seasons being favourable or otherwise. The yield is generally greatest in the autumn in the October crop, probably on account of foliage of the *Dhak* trees being better and more tender. The summer crop collected in June is usually smaller." Yield.

138. "Too much or too little rain retards the growth of lac as well as forest fires. A kind of flying insect with wings like a butterfly eats up the lac, also a kind of spider eats up the whitish parts. These insects are killed by the lac growers." Pests.

139. "Lac is rarely found in the Government forests and is grown on a small scale on *Dhak* trees only in some private lands. Experiments to grow lac in Government forests at Ranipur have hitherto failed. Further experiments will be made next July."

Central Provinces.

140. Following the course already pursued with other provinces it may be useful to furnish a selection from the more important published reports and official correspondence in exemplification of certain historic facts and of the extent of present knowledge regarding the production of lac in these provinces. The following passages taken from the District Settlement Reports may be viewed as interesting in CULTIVATION IN THE CENTRAL PROVINCES.

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that they mark the position of the industry 20 or 30 years prior to the more recent and fuller reports that are now available :—

Bilaspore District.

Extract from the Report on the Land Revenue Settlement of the Bilaspore District, Central Provinces (pages 77 and 87) by* J. W. Chisholm, *1869.

141. Of industrial products the most extensively in demand is lac . . . .

The *kusam* trees on which it is found yield from 20 to 30 lbs., a portion being left for seed, or, in other words, to reproduce the material in demand, and the annual value of a tree runs from 3 to 4 rupees. As a consequence the '*kusam*' is very rarely cut down and is invariably preserved as a valuable property."

"The lac trade represents an important item, the average export of the last four years being nearly 15,000 maunds, aggregating a value of about two and-a-half lakhs of rupees. This is not, however, entirely from this district (Bilaspore), but from all Chattisgarh. The grain lac from both districts (Bilaspore and Chattisgarh) proceed over the same lines to Mirzapur and Jubbulpore. The stick-lac is purchased up by agents of firms at low rates, and must yield a large profit to the purchasers compared with the small returns the actual collectors receive. No mere local resident, however, has found it a remunerative process to export on his own account, the manufacture of the dye being almost a monopoly. The whole business therefore is carried on by agents on the spot who despatch the commodity at the instance of the firms employing them. The expansion of the trade is not a likely contingency, as the demand fluctuates and the '*kusam*' trees on which the lac insects are fostered are somewhat limited in number.

Raipore District.

Extract from the Report on the Land Revenue Settlement of the Raipore District, Central Provinces (pages 76 and 77) by* J. F. K. Hewitt, Esq., B.C.S., *1869.

Season and Method of Propagation.

142. The lac trade owes its origin to the Mirzapore and Jubbulpore merchants who export yearly large quantities from Raipore. It is chiefly produced on the *kusam* and *palas* trees, but the produce of the former is twice as valuable as that of the latter. The mode of propagation on both trees is similar but takes place at different seasons of the year; the propagation of the most important crop, that of the *kusam* lac, is begun at the end of January or February. At that time freshly-cut sticks, on which the lac insect has made its cells, are wrapped in bundles of grass and tied on to the branches of the tree on which the new lac is to be grown, four bundles being generally the complement for one tree; and from these centres the insects propagate themselves in all directions, covering all the smaller twigs with their excretions. The crop is collected in the month of November or December following the sowing, and the yield very much depends upon the quantity of rain: the light

Influence of Rain.

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rains bringing a light crop. The process of propagating lac on the *palas* tree is similar to that described above, except that the process is begun in September and October and the crop gathered in the following July.

Sales.

143. The cultivation of the lac is the occupation of the wild Gonds, Boonjias, Nahurs and Khamars of the jungles, and they sell the crop to middlemen who again dispose of it to the great dealers who live chiefly in Dhumburry, Rajim, Balod, and Arung. The trade of these middlemen is said to be a speculative one, as in some years they get very large profits on the prices paid to the producers, and at other times they hardly pay their expenses. The price in the jungles varies from 15 to 35 rupees per *bhoja* of 12 maunds and 16 seers each, and that paid by the merchants from about 25 to 80 rupees. But though it may occasionally happen that the middlemen may make a bad bargain, the writer believes that, as a rule, they generally make a very comfortable profit.

144. One of the most interesting papers on the subject of the lac industry of the Central Provinces is the account furnished in 1875 by Mr. J. McKee of the Forest Department. This not only gives full particulars as to the local methods of production and the extent of the trade but publishes the results of highly instructive experiments performed under Mr. McKee's personal supervision. More recent experiments conducted at the instance of the Inspector-General of Forests may be said to have carried the enquiry down to within the past few years. Mr. McKee's paper appeared originally in the *Indian Forester* (Vol. I., page 269 (1876), was partly republished by Mr. J. E. O'Conor in the revised edition of his most admirable work on *Lac Production, Manufacture and Trade* and has thus been before the public for many years. I shall accordingly content myself with quoting only the more instructive passages from Mr. McKee's report and I do so with a view to exhibit his personal opinions and the extent of his investigations :—

Extent of Trade.

145. "At present nearly all the lac is collected by private individuals from the unreserved and private forests; in the former the right being sold annually to the highest bidder, while in the latter most of the large firms interested in its manufacture have obtained leases ranging in periods from 8 to 10 years—a tenure which gives them the opportunity of increasing by cultivation the ordinary natural yield. It is well known that large sums of money, amounting latterly to about 15 lakhs annually, are circulated throughout the Province in the collection and manufacture of this material, much of which, as before stated, is obtained from the Government forests, but, strange to say, in spite of its being usually classed as one of the most available minor forest products, the State has never up to this time reaped any considerable gain by its sale, probably not more than R15,000 per annum."

Discussing the question of State cultivation Mr. McKee wrote :—

146. "With regard to the cost, this will necessarily vary with the description of the trees employed for the purpose, and the proportion

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they bear to one another in numbers on a given area. Such trees as *palas* (**Butea frondosa**) and *ber* (**Zizyphus Jujuba**) which are of comparatively small size, and which are found in many places in a state of almost pure forests, will necessarily cost less to bring under cultivation than larger species, such as *Kusam* (**Schleichera trijuga**), *guler* (**Ficus glomerata**), and *peepal* (**Ficus religiosa**), which are generally found either scattered about the forests or fringing the slopes of ravines and the banks of the rivers for less brood lac will be required for their treatment and less trouble and time employed in searching for them; but, on the other hand, the larger outturn obtained from the latter species will more than repay the extra money expended in preparing them. Our experiments extend at present to having operated on 7,467 trees of the *Palas* and smaller species and 1,903 trees of *Kusam;* these numbers represent the standards on which the insects are doing well and do not include a large percentage which turned out failures. The total cost of bringing the above under cultivation, including all charges, such as collecting brood lac, attaching it to the trees, etc., average R3-5-11 per 100 trees of *Palas* and R15 per 100 trees of *Kusam*."

Experiments in State Cultivation.

Cost.

Hot winds.

147. "Owing to the dryness of our summer and the great damage to the lac caused by the hot winds, it does not seem probable that we can look forward to even two good crops in the year; the summer one will probably in almost all places, except those where favourably situated, be of poor quality and quantity of lac developed not more than sufficient to leave on the trees for producing the crop which matures during the cold season. This latter will generally be good and must be the one we depend on for a return. Reckoning, then, on only one crop a year, and estimating the yield per tree at the moderate quantities of 3 seers for *Palas* and 15 seers for *Kusam* or trees of like size, we obtain a net outturn, after deducting 25 per cent. for wastage in drying and packing, from the *Palas* and small trees of maunds 5·25 per 100 trees, and from the larger species of maunds 27·32, which, if valued at R15 and R20 per maund, respectively, will be worth R84-6 for the former, and R541 for the latter. Take from these sums the cost of producing the article, which in future will be, if anything, less than heretofore, owing to the lac being obtained in one spot, and the net profits on 100 trees of *Palas* will equal R81 and on the same number of *Kusam* R526. Large areas of forest are now available on which the number of *Palas* and other suitable trees per acre quite equal or even excel the above unit, and the expediency of forming plantations of *Kusam*, which area for area would yield a more valuable crop, is under consideration."

Yield.

148. Mr. McKee gives a list of 17 trees as those on which the lac is generally found. These have been included in the combined enumeration, para. 64, which represents the good plants of the whole of India. Mr. McKee then remarks:—"Of the above trees the light golden resin obtained from the *Kusam* is the finest, as from it the most valuable orange shell-lac is manufactured, and next in quality is that obtained from the *Palas* which yields the garnet lac of commerce. Wherever possible, therefore the *Kusam* tree should be chosen for

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Varying Properties.

standards; but as the *Palas* is generally found in much greater numbers, area for area, its produce will nearly compensate in quantity for the reduction in its value. Having selected the forest for experiment, the next point to fix on is the local date on which the insects leave the parent cells, a step of great importance, and one on which the first success of the plantation will very greatly depend as, should the work of gathering brood lac be delayed until visual proof of the exit of larvæ is obtained, a vast quantity will be killed in the operations of collection, transport, and of tying the encrusted twigs on the standards selected for nurseries. The date of evolution having been fixed on with some certainty, twigs of that season's lac should be gathered about 15 days before, wrapped up in a few straws of grass and attached to the trees selected for production, with threads of *Palas* root fibre or something else as easily obtained; each twig should be from 9″ to 1′ in length, and be attached to the upper and middle branches of the tree. The grass tied round the twigs acts as a means of communication, from the lac to the branches and leaf petioles, by which many insects are saved that would otherwise die from want of nourishment; as owing to the crookedness and irregularities of the encrustations contact between them and the branches is seldom complete. It is also of importance to tie the brood lac to the upper and middle branches, as many of the lower ones, by this arrangement, become covered with insects, which are shaken or fall from above; whereas if the lac be attached to the lower portion of the tree, many larvæ must fall to the ground and be lost; when attaching the twigs it appears necessary to take care that the wood of the standard is not of denser composition than the wood of the tree from which the brood lac is gathered, as it is believed that the larvæ reared on soft-wooded trees are comparatively weaker than those which are found on species of harder texture. There is an idea prevalent among the Gonds that nursery standards must be prepared with brood lac taken from the same species as themselves; but this has been proved to be incorrect. The brood lac yielded by the *Kusam*, a very hard wooded tree, appears best suited for propagating purposes, as it succeeds on trees of all other species. When several trees of the selected species grow together it does not appear necessary at first to artificially cultivate more than three-fourths of them, as during the succeeding evolution the remaining fourth will almost certainly be brought under preparation by natural means,* but as the success of the crop depends principally on the supply of juices obtained by the female insects during the period they continue to deposit the resin, it is necessary to place the brood lac on the youngest and most sappy branches."

Method of Propagation.

Position of Attachment.

Natural Reproduction.

* "In 1874, 1,300 trees were prepared at Kosai in the Satpura Reserve, in 429 of which the lac was destroyed during the hot weather of 1875, leaving 871, from the encrustations of which a new brood of larvæ swarmed in July 1875. The lac on these trees was not touched owing to its being a bad crop, but was left for further propagating purposes. On the 19th August, however, an enumeration of the trees on this spot proved that new lac was then being formed on 1,380 trees; thus 509 trees must have been affected by their proximity to the old standards."

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149. "Lac preserves may be formed by carrying out the above simple operations; but it is not probable that success will be attained at once or until experience has drawn attention to several peculiarities in the habits of the insect and the manner in which it is influenced by situation and atmospheric conditions. Our first attempts were made in the cold weather of 1874, but owing to the want of knowledge that prevailed on several essential points, both among the superintending staff and the labourers employed on the work, the extent of these was naturally limited and of small result. It was not known with any certainty when the exit of young larvæ commenced or what was the best method of applying them to the trees; thus a large number were lost, and this destruction of insect life was greatly increased by the rough handling they were exposed to by the workmen. In one instance a plantation which had been prepared and was progressing well was nearly destroyed by mistaking an evolution of male insects for one of larvæ,—an error into which it would not be possible to fall except through want of knowledge of the insect habits; in another, the colonies were greatly damaged by a fire which broke out and destroyed the lac—on all but the highest trees; while in a third, frost and hot winds killed the females and stopped the formation of lac on nearly half the number of trees prepared. But although we had to contend with so many mishaps, partly through ignorance and partly from physical causes, each experience in its way brought valuable information which will render more certain our future undertakings."

Male Insects.
Conf. with p. 11.

Propagation Sticks or Brood Lac.

150. "Of the points to be noted in making these preserves, the one of the greatest importance perhaps is the fact that the lac encrustations may be plucked several days before the larvæ appear,—a knowledge of which will enable a larger number of trees to be prepared during the working season than if it was necessary to delay the operations until the evolution actually took place, as, owing to this latter being barely simultaneous in and about one locality, the period for forming the plantation must be necessarily limited to the number of days it takes the cells to become empty; besides which, by attaching the lac twigs before the birth of the larvæ great numbers are saved, which would otherwise perish during the process of being attached to the trees. In support of this fact it will be interesting to give the following observations: Mr. Thomson, Deputy Conservator, in order to fix on a safe date for gathering the brood lac, caused twigs, covered with the encrustation, to be brought in from the surrounding forests every two days for examination. These he labelled, dated and hung up in the verandah of his forest bungalow; the first twig was gathered on the 10th June, and the others on every succeeding alternate day until the 12th July. These twigs were the produce of several trees, and were brought from various parts of the forest within a radius of 10 miles; some were plucked from the *Guler*, others from the *Pipal*, but the majority from the *Palas*. On the morning of the 13th July, according to custom, Mr. Thomson examined the twigs, but found no sign that the larvæ had vacated their cells although microscopic observations

Survival of insects after Separation of twigs.

had proved them to be fully developed. On the 14th, however, an inspection showed that on all the twigs without exception, the young were pouring out of the cells through the anal apertures; thus the twig gathered on the 10th June hatched exactly on the same date as the one gathered on the 12th July, or more than a month later." "While on this subject it is necessary to draw attention to the reported variation in the number of evolutions and consequently in the number of crops which are obtained in different countries. In Mysore and Burma it would appear that three evolutions of the insects take place during the year."

CULTIVATION IN THE CENTRAL PROVINCES.

Climate.

Discussing the influence of climate **Mr. McKee** says:—

151. "This no doubt is the reason why in districts where the seasons are dry and where showers are of unfrequent occurrence during the hot weather, the summer crop is invariably poor and scarcely worth collecting. Moisture is one of the great essentials for a fine crop of lac, and many disappointments, if not total failure, will result by fixing on dry arid spots for the formation of the plantations. The females cannot obtain sufficient nourishment at this period from the sapless stems, and their death will be recognised by the pitted appearance assumed by the cells, the crowns of which fall in as the insect contracts within them, and by the cessation of the growth or disappearance of the white filaments which obtrude from the spiracular orifices, species such as *Kusam* and *Guler*, which most frequently are found growing along the banks of rivers, where the atmosphere is humid and moist, are, for these reasons, especially adapted for yielding good crops of lac; while the *Palas* offers advantages, as its sap-producing functions are actively employed during the hottest season of the year when it forms both new wood and leaves."

Necessity of Moisture.

Death of Females.

The Conservator of Forests, Central Provinces, Nagpur, furnishes the following instructive particulars in a letter, dated 8th January 1894, to the address of the Inspector General of Forests:—

152. "With reference to your demi-official Circular No. 1 of the 3rd January 1894, I have for the present to communicate the following remarks and information:—

Rise in Prices.

"Some years since the production of lac was taken up departmentally; it proved very successful, was supplemented by much spontaneous production, and proved highly profitable, for the prices had then run up to the highest figure attained, a fact due, it is believed, to the whole of the stock in the London market having fallen into the hands of two or three individuals who worked together. After this came the crash and the price of lac fell so low that the artificial production for a time ceased to pay. It again revived to some extent; but it has to contend with varying climatic conditions and for one or two years these have been altogether against the production of lac."

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153. "For the last three years I have been struggling to encourage production in the Eastern forests of this circle, where there is a good deal of **Schleichera trijuga** which yields the finest lac both as regards its quality and capacity for standing storage; but it has been impossible to obtain any supply worth mentioning of good seed lac and consequently little or no progress has been made."

Failure.

154. "During the year 1891-92 the insects appear to have completely disappeared from the Government Forests of Raipur and Bilaspur, and I have been addressed by a private firm, in the habit of drawing their supplies from private forests in that region, enquiring whether or not there was truth in the report of the sudden failure of the crop in that part of the country."

Forest Villages are necessary for obtaining much lac.

155. "It is worthy of note that while this almost total failure occurred in Chhattishgarh, an unusually good crop was obtained along the base of the Satpura hills, about 60 miles north of Nagpur. There can be no question that the lac industry is a somewhat precarious one, but it is equally certain that this, as well as other industries, could be largely developed if but we had a stronger establishment and more *bonâ fide* forest villages inhabited by people, who doing a little cultivation, just sufficient to obtain a supply of grain, devote the rest of their time to forest work. But the establishment is at present altogether insufficient, and though for this also the local officers are not responsible, the organisation is most defective, and though it may save a few rupees, is not economical, and here I may note that I only regard that organisation as economical which will bring in the largest return per cent. on the outlay incurred."

Experimental Cultivation of Lac in the Central Provinces. Forest Administration Report, Central Provinces, 1894-95 and subsequent issues.

Experiments conducted.

156. In Bilaspur, in the Kuajathi-Pantora Range, seed lac was placed (1894-95) on 100 *palas* and 50 *kusam* trees. It is reported to have succeeded on the former, but to have failed on the latter, owing to heavy rain, which swept the insects off the trees.

Heavy Rain.

In Chanda, during July 1894, an area of 4 acres was chosen in the Moharli Range and brood lac tried on 100 selected *palas* trees. The undertaking was quite successful; so last June the experiment was extended to 60 acres in the Moharli Range and 450 acres near Ragri in the Warora Range, 396 trees being prepared in the former and 200 trees in the latter at a cost of only R17.

The results of this experiment will be watched carefully and reported on next year.

Reports of Results attained.

157. In Betul, lac was propagated over a wide area, and the Divisional Forest Officer is sanguine of success. A similar experiment carried out previously in this Division proved a success.

For the year 1896-97 it was reported that in the Chanda Division the working of the lac industry during the year had not been favourable, as only a small number of trees were put under cultivation, in

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consequence of a very small quantity of brood lac being obtainable; 453 trees on 22 acres were operated on for lac at a cost of R1-8-0, which yielded lac valued at R5-8-0. A complete failure in this connection resulted this year also in the Warora Range.

CULTIVATION IN THE CENTRAL PROVINCES. (Bilaspore District.)

158. For the year 1896-97, (page 18—Northern Circle) it was reported:—The opportunity given by the cancellation of nearly all the lac leases in consequence of the forests having been thrown open to all-comers in search of edible products, etc., was seized to undertake propagation by departmental agency. The remarkable financial success scored by the Rewah State in the exploitation of lac proves beyond doubt that the business is capable of very great expansion in this Circle, especially in the Mandla and Jubbulpore Divisions, in the Satpura portion of the Narsingpur and Hoshangabad Divisions, and in the moister parts of the Betul Division.

Results attained in Rewah State.

In Mandla nothing could be done as seed lac was not procurable. In Jubbulpore experiments were successfully carried out in the Marwara, Sihora and Jubbulpore Ranges. In Damoh 800 *ghont* and *palas* trees were sown at a cost of R100. In Saugor experiments, costing R4-1-6, were tried in the Jaisinghanagar, Jamunia and Oria forests, the results so far being satisfactory in the first two forests and a complete failure in the third. In Betul work was undertaken on a considerable scale, although without expenditure; but the long drought that prevailed and hot winds proved fatal when the insects had made some progress.

159. For the year 1897-98, (page 27—Southern Circle) it was reported:—In the Chanda Division, it is reported that the lac experiments showed very unfavourable results. Trees 84, over two acres, were operated upon at a cost of R1-4-0, the lac obtained being 1 seer. Want of brood lac prevented more trees being put under cultivation. The Forest Divisional Officer believes that this industry has a good future before it, if fostered by care and supervision, to the want of which he ascribes past failures. The matter will receive more attention.

Berar.

CULTIVATION IN BERAR.

160. The following series of letters and reports give the latest available information regarding the experiments performed to extend the production and trade in lac in the Hyderabad Assigned Districts (Berar):—

Copy of letter No. 217, dated the 9th July 1894, from the Conservator of Forests, Hyderabad Assigned Districts.

161. I have the honour to thank you for your demi-official Circular No. 1, dated 3rd January 1894, and for the hints therein given regarding the advantages of lac culture.

I beg, as requested, to put up a memorandum noting the information I have been able to collect regarding lac in Berar, giving my

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opinion on the subject and detailing action taken and proposed to be taken, in connection with the extended culture of this valuable minor product of our forests :—

"Enquiries regarding the *propagation* of the lac insect and the present sales of lac from Berar have been made on the Inspector General of Forests' demi-official Circular No. 1, dated 3rd January 1894.

162. "It appears there is little or no culture of lac in Amraoti, Akola and Buldana, and there are no facilities for starting the culture.

Royalty.

"In the Ellichpur Division there is a considerable export of lac; as the royalty levied does not exceed 6 pies a seer and R978-7-6 being the collection of the last year, the outturn must have been near 800 maunds. In the Melghat Forests of this Division there are facilities for cultivating lac in the fire-protected forests on *Palas*, *Pipal*, *Ber* and *Kusam* trees, and it is proposed to start work through the Kurkus, an aboriginal race, already accustomed to collect lac.

"There seems to be no reason, why the price charged for lac should not be raised.

163. "In the Basim Division lac is found in the Kinwat Reserve, and the right to collect has hitherto been sold by auction. In 1893 the right was auctioned for R20 only, but enquiry shows that the export certainly amounted to 40 maunds, so that even at Ellichpur rates R50 should have been realized.

"The presence of forest villages of Kols and other wild tribes in Kinwat render it easy to extend the culture of lac, and it may be well for one or two seasons to pay for culture and collection, and sell the outturn in bulk departmentally.

164. "In Wun Division there have hitherto been only nominal returns from lac in State Forests, though a certain amount has been collected and sold in the forests of leased villages.

Profits.

"Since the receipt of the Inspector General's Note a collection of lac has been made, and Mr. Mansukh Rai consigned it to Messrs. Ernsthausen & Co., Calcutta. The consignment consisted of 3 maunds 26 seers of stick lac, noted as 2nd quality by the Agents which sold by auction for R87-9-6. Deducting the carriage by rail to Calcutta, agents' charges and commission, the net amount realized was R73-15-0 or about 8 annas a seer against 4 annas a seer for which the stick lac sells locally.

"It is proposed to cultivate lac in the Kelapur, Anjankher and Lonbehel fire-protected reserves of the Wun Division, where there are facilities as to suitable forest growth and labour for cultivation and collection.

165. "As to Berar in general it may be said that lac has hitherto received no attention, that there are facilities for extending the cultivation and collection of this valuable product, and that apparently sales of lac should rise to many thousands a year within a comparatively short period of time. Whereas in Berar we have so many reserves under recuperation which at present give no direct

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returns, the culture of lac may enable us to create a new source of revenue, and at the same time increase wage-earning in the wilder and poorer parts of the country. CULTIVATION IN BERAR.

"Four points are :—

1st.—No land has hitherto been set aside for lac culture, and only the outturn of spontaneous production has been exported. Prospects of Increased Production.

2nd.—There appear to be facilities for largely increasing the production of lac, but I cannot estimate the probable area or outturn.

3rd.—I can give no figures as to the annual ratio of increase.

4th.—The culture of lac only affects the least valuable part of our forest growth, and I know of no objections to extended and systematic cultivation of lac.

166. "As to conditions under which cultivation might be carried out I fear no agents would be ready to start work in the malarious forests on the Tapti and Penganga rivers, but if they are, very easy terms will be given provided such agents will undertake to produce a certain minimum amount of lac or in lieu pay a minimum sum per annum by way of profit."

Memo., dated 26th May 1897, on Lac Culture and Sales in Berar by the Conservator of Forests, Hyderabad Assigned Districts.

167. "The most extended experiments as to lac culture have been made in the Ellichpur Division and a memo. (enclosure No. 1 (*see* p. 250)) on the subject, by the Deputy Conservator of Forests in charge, is attached. Review of Recent Experiment.

"In the Amraoti Forest lac culture has only just started and it is too early to quote results. The yearly sales from old lac are *nil.*

"In the Akola Forests culture is being started in 1897-98. The average annual receipts from naturally grown lac are only R22-8-0.

"In the Buldana Forests lac-bearing trees are few in number and lac culture could not pay.

"The Basim Forests are most promising as to lac culture. A note on subject by the Divisional Officer is attached (enclosure No. 2 (*see* p. 256)).

"In the Wun Forests the progress to date is disappointing. A memo. (enclosure No. 3 (*see* p. 257) by the Divisional Officer is attached.

168. "In the years 1895-96 and 1896-97 the early rains were heavy, but the later rain failed and from September onwards in each year there was drought. Lac culture seems to demand normal moisture and during these two years the 1894-95 experiments which promised success have failed. The lac sales have, as might be expected, fallen off. Climatic Conditions Necessary.

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"The receipts for all forests in Berar were :—

	R
1893-94	567
1894-95	2,489
1895-96	2,052

and 1896-97 will be worse.

"I believe, however, lac will pay and experimental culture will be pushed."

ENCLOSURE NO. 1

Note on Lac by* Mr. R. M. Williamson, *Deputy Conservator of Forests, Ellichpur Division.

Experimental Cultivation.

169. "The details of the species of trees experimented with and the expenditure and revenue from lac are given in the 4 forms attached. Form No. 1 (*see* pp. 252-253) shows the lac cultivation in 1894-95, 1895-96 with species of trees in each range.

"The Rangers report that the largest percentage of success was obtained on *Palas* (**Butea frondosa**) and *Ghatber* (**Zizyphus xylopyra**), but no definite figures are available, small success was for some reason met with in stocking trees of other species, the lac spreading a short distance and then dying off. This may have been due to climatic causes.

"Form No. 2 (*see* p. 254) shows the expenditure on departmental cultivation and collection of lac with the price at which it was on the spot (*i.e.*, at certain centres) in Bairagarh and Gugamal sold by tender Reserves in 1894-95 and 1895-96, respectively.

First Year Poor Return.

170. "The departmental collection of lac was not entirely from trees departmentally stocked in the two years, but included some from previously existing sources. This and the fact that the lac does not spread very far in the first year after stocking and consequently does not give immediate return for the expenditure, render impossible any useful comparison of the figures of expenditure and revenue as quoted in the Form. A greater length of time must elapse before a definite estimate of the possible financial results can be made.

"Form No. 3 (*see* p. 255) shows the total revenue from lac in Gugamal and Bairagarh Reserves from 1893 to 1895-96, whether departmentally collected or by purchaser.

Prices.

"Form No. 4 (*see* p. 256) shows the revenue from lac from CIII Forests paid at the forest sale depôts at the rates noted respectively. It is exported as stick lac and is understood to sell in Ellichpur market at 4-5 annas per seer, the supply being eagerlv bought up, whereas the lac collected departmentally and sold by tender for the whole —fetches only R1 for 9 seers, in the case of stick lac, and R1 for $4\frac{1}{2}$ seers, in the case of seed lac, in the Reserves.

171. "As to the future prospects of the lac cultivation it is to be hoped that as the results of artificial cultivation make themselves more marked (the lac spreading in the course of nature to surrounding trees as well as on the actual trees stocked), and as greater skill is

attained in the process of attaching the lac, that a much larger return will be obtained. Much depends, however, on the cost of collection and the price obtainable. Hitherto the wages paid for collection of seed lac has varied from $1\frac{1}{2}$ annas to 2 annas per seer, while for seed lac it has ranged from 2 annas a seer to R1 per 5 seers. It is hoped that $1\frac{1}{2}$ anna for stick lac and $2\frac{1}{2}$ annas for seed lac may be found sufficient. CULTIVATION IN THE HYDERABAD ASSIGNED DISTRICTS, BERAR.

172 "Also, as stated in paragraph 5, the prices obtained by departmental sale leave much to be desired. As an experiment the District Forest Officer this year refused the only tender received (the same in amount as that last year) and has decided to sell stick lac from the Reserves in the open market in moderate quantities by public auction. Unless better prices can be obtained the margin of profit will remain very small. The experiment is, however, only commencing and it is too soon to form any accurate idea as to the future results. The experiment is, however, in the District Forest Officer's opinion well worth continuing." Difficulties of the Trade.

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PRODUCTION IN BERAR.

FORM No 1.

Cultivation of Lac in 1894-95 (Forest Year).

YEAR.	Month when Lac was put on the trees.	NUMBER OF TREES ON WHICH LAC WAS PLACED.											Total No. of trees.	Cost.
		Palas.	Kusamb.	Ghoti.	Pipal.	Ber.	Bur.	Tiwas.	Salai.	Lendya.	Gular.	Feper.		
1894-95.														R a. p.
Sembadoh Circle	June 1895 .	No detail is available.											5,467	17 12 0
Chaorakund ,, ...	Ditto .	19,413	277	1,503	143	2,043	6	...	...	...	...	...	23,385	37 12 0
Butram ,, ...	Ditto .	19,662	833	3,693	30	6,350	52	...	...	...	353	37	31,010	44 1 0
Khandu ,, ...	Ditto .	2,378	628	771	...	78	...	...	...	...	15	...	3,870	6 6 0
Gugamal ,, ...		4,620	1,836	1,780	146	782	...	1,113	4	8	...	...	10,289	86 6 0
												TOTAL .	74,021	192 5 0

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PRODUCTION in BERAR.

FORM No. 1—*contd.*

Cultivation of Lac in 1895-96 (Forest Year).

Year.	Month when Lac was put on the trees.	Number of trees on which Lac was placed.									Total No. of trees.	Cost.		
		Palas.	Kusamb.	Ghoti.	Ber.	Tiwas.	Gular.	Pakar.	Pipal.	Bur.		R	a.	p.
1895-96.														
Sembadoh	June 1896	6,485	3,909	5,246	5,105	4,000	...	20	9	60	24,834	28	11	0
Chaorakund	May 1896	2,514	146	...	...	...	...	...	...	...	2,660	7	4	6
	June 1896	2,200	50	...	...	...	...	...	...	...	13,480	26	2	0
	Ditto	8,687	370	2,066	35	...	70	...	1	1				
Butrum	May 1896	10,282	500	2,400	4,800	...	...	...	25	600	18,607	44	10	0
	June 1896	7,816	533	1,493	2,050	...	53	17	30	52	12,044	12	2	0
Khandu	Ditto	15,200	2,320	1,949	1,320	300	...	...	...	...	21,089	21	12	0
Gugamal	November 1895	571	128	714	370	944	...	...	...	...	2,727	20	0	0
										Total	95,441	160	9	6

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PRODUCTION IN BERAR.

FORM No. 2.

Statement showing Amount spent in Cultivation (attaching Lac), Collection and Sale Price.

YEAR.	AMOUNT AND COST OF CULTIVATION—(attaching).		AMOUNT AND COST OF COLLECTION OF LAC.			Sale price.	REMARKS.
	No. of trees.	Cost.	No. of seers collected.	Cost per seer for collection.	Total cost.		
		R a. p.		R a. p.	R a. p.	R a. p.	
1894-95 . . .	74,021	192 5 0	520	0 1 6	46 12 0	130 0 0	
1895-96 . . .	95,441	160 9 6	(a) 614½ (b) 263	various 0 2 0 to 0 3 0	141 9 6	168 7 10 29 3 2	(a) Seed-lac. (b) Stick-lac.

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FORM No. 3.

Statement showing Sale of Seed-lac and Stick-lac in Bairagarh and Gugamal Reserves from 1893-94 to 1895-96.

YEAR.	Reserve and range.	No. of seers collected.	COST OF COLLECTION. Rate per seer.	COST OF COLLECTION. TOTAL.	PRICE OBTAINED. Rate.	PRICE OBTAINED. Per	PRICE OBTAINED. TOTAL.	REMARKS.
				R a. p.	R a. p.		R a. p.	
1893-94	Bairagarh	(a) 164 Head load	Collected by exporters.	...	0 6 0	Head load.	61 8 0	(a) Stick-lac. (b) Seed-lac.
	Gugamal	(a) 19 Ditto		...	0 6 0	Ditto	7 2 0	
1894-95	Bairagarh	(b) 520 seers	R0-1-6 per seer.	48 12 0	0 4 0	Seer	130 0 0	
	Gugamal	(a) 317 Head load	Collected by exporters.	...	0 6 0	Head load	118 14 0	
		(a) 56 Ditto		...	0 6 0	...	21 0 0	
1895-96	Bairagarh	(b) 459½ seers	5 seers to a rupee	118 12 0	4½ seers	Rupee	131 5 4	
		(b) 25 Ditto			0 4 0	Seer	8 4 3	
		(a) 263 ...	11 seers to a rupee		9 seers	Rupee	29 3 2	
	Gugamal	(b) 130 seers	R0-2-0 per seer.	16 4 0	4½ seers	Rupee	28 14 3	

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FORM No. 4.

Revenue from Lac (stick-lac) in 1893-94 to 1895-96.

Year.	Quantity.	Rate.	Revenue. R	a.	p.
1893-94	13 Cart loads . . . 22 Bullock loads . . . 24 Donkey loads . . . 545 Head loads . . .	...	303	6	0
1894-95	11 Cart loads . . . . 30 Bullock loads . . . 12 Donkey loads . . . 809 Head loads . . .	...	394	6	0
1895-96	13 Cart loads . . . . 11 Bullock loads . . . 6 Donkey loads . . . 814 Head loads . . .	...	384	8	0
		TOTAL .	1,082	4	0

ENCLOSURE No. 2.

Note on Lac in the Basim Division by* Mr. C. H. Haldane, *Divisional Forest Officer, Basim Division.

Results of Experiments.

173. "The monopoly to collect lac in the Kinwat and Marwadi Reserves was sold in 1893 by auction for R20 and R12, respectively, but it was noticed that the Reserves could yield a very much larger quantity with culture. Consequently in 1894-95 its culture was undertaken and the insect attached to 4,650 trees in Kinwat and 2,434 trees in Marwadi, the work costing R7-2-0 and R15, respectively. The result in the former case was a success as the figures given below will show, but not in Marwadi owing to the small extent of '*tiwas*' on which the insect is usually found in these parts.

"In 1895-96 propagation was only undertaken in Kinwat where it cost R15-8-0, but the yield was comparatively poor owing to the excessive dry heat of the last hot season by which the insect was almost exterminated as was seen from the collections made in June last.

"Of the other areas Gahuli alone, where culture is contemplated this season, the lac insect is noticed to a small extent.

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CULTIVATION IN BERAR.

174. "The outturn of lac during the last three forest years is as follows :—

Year.	Quantity in seers.	Average rate per maund.	Value.	Expenditure.
		R. a. p.	*R. a. p.*	*R. a. p.*
1893-94 .	...	Auction.	32 0 0	*Nil.*
1894-95 .	2,491	20 8 0	1,280 0 0	175 0 0
1895-96 .	1,997	15 8 0	750 0 0	113 0 0

Promising.

"As regards the future prospects of lac, the Divisional Forest Officer is of opinion that there is no reason why the outturn in a few years in Kinwat should not double itself with annual culture and proper supervision during collection. Also in Gahuli State Forest A he is of opinion that lac could be successfully propagated.

"In Marwadi prospects are poor for want of more '*tiwas*' and other trees on which the insect usually thrives."

Enclosure No. 3.

Note by* Mr. Mansukh Rai, *Divisional Forest Officer, Wun Division.

175. "In 1894-95 lac cultivation was attempted in the following Reserves :—

Kelapur	Reserve about	. . . .	2,000 Acres.
Anjankhed	do. do.	. . . .	2,000 "
Pathroat	do. do.	. . . .	500 "

Failure

"In Kelapur propagation of lac succeeded fairly well, but in Anjankhed and Pathroat the experiment was a failure. Only a very few trees were seen doing well. In 1895-96 no work under this head was undertaken. In the current year, too, it is reported by Rangers that owing to scanty rainfall lac seed is very scarce and any, if propagated now, is not likely to succeed.

"The receipts have been as follows :—

	R.	*a.*	*p.*
1893-94	163	3	0
1894-95	519	8	0
1895-96	700	0	0

"During the current year 1896-97 receipts are not expected to reach R500.

"Lac is chiefly found in the Kelapur Taluk.

176. "In my opinion the past experiment has been a failure. No proper information was recorded by the Foresters, etc. Now that we have got intelligent establishment the experiment will be

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CULTIVATION IN BERAR.

regularly made and results recorded in a separate note book supplied to each Ranger for the purpose. I think the lac cultivation will be a paying concern in the Wun District."

Central India and Rajputana.

177. Very little is known regarding the production of lac in these regions. That there must be a considerable trade in the product is abundantly demonstrated by the high perfection to which the art of ornamentation with lac has been carried.

CULTIVATION IN CENTRAL INDIA.

178. Forsyth (*Highlands of Central India, published 1872*) alludes repeatedly to the substance and the trees on which it is produced. The following passage from that work may, therefore, be read with interest :—

"Stick-lac of commerce is deposited by an insect on the smaller twigs of several species of trees among which **Butea frondosa, Schleichera trijuga** and **Zizyphus Jujuba** are the principal. The twigs are broken off, and sold as they stand, looking like pieces of very dark red coral. About twenty pounds will be procured annually from a tree, so long as any of the insects are left on it to breed. But just as often as not the improvident wild man will cut down the whole tree to save himself the trouble of climbing. The inborn destructiveness of these jungle people to trees is certainly very extraordinary; even where it is clearly against their own interest, they cannot apparently refrain from doing wanton injury. A Gond or Byga passing along a pathway will almost certainly, and apparently unconsciously, drop his axe from the shoulder on any young sapling that may be growing by its side, and almost everywhere young trees so situated will be found cut half through in this manner. The stick-lac is manufactured into dye in considerable quantities at a Factory in Jubbulpore, established by a gentleman (Mr. Williams) who has long since retired, after realising the success so well deserved by his remarkable foresight and enterprise. The agents of this Factory penetrate the remotest corners of these jungles in search of the raw material; and the development of this profitable business, during many years of patient and fair dealing with these timid savages, is a valuable example to those who would follow Mr. Williams' steps in the development of the many latent resources of these regions."

Punjab.

CULTIVATION IN THE PUNJAB.

179. Although the art of ornamentation with lac has been carried to a very much higher state of perfection in the Punjab than in any other province, the production of, and trade in, the crude article has by no means attained the same position of importance as in most of the

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other provinces. It might be viewed in the Punjab as a local product, which is taken full advantage of in the indigenous industries, whereas with Bengal, the Central Provinces, and Assam it has from almost the earliest times of British commerce been looked upon as a valuable item for foreign export although one which is but indifferently utilised by local industries. CULTIVATION IN THE PUNJAB.

180. One of the earliest writers on the Punjab may be said to have been the late Mr. H. Baden-Powell, C.I.E., who (in his *Economic Products of the Punjab, 1868-72*) gave an instructive sketch of the trade in this substance. The following passages may, therefore, be usefully recorded here from that great work :—

Passages taken from the Hand-book of the Economic Products of the Punjab, Vol. I., pages 190-94, 1868, by* H. Baden-Powell.

181. "The lac insect is found more or less all over India; in the Punjab it is universal, and there is scarcely a district which does not exhibit a sample. Baden-Powell's account, in 1868 A.D.

"The lac exhibited is almost exclusively the produce of one or other of the three trees 'pipal' (**Ficus religiosa**), 'dhak' (**Butea frondosa**), or 'ber' (**Zizyphus Jujuba**). The *dhak* specimens have been sent from Kangra District, and also from Kapurthalla. The '*ber*' lac is the commonest; it is much produced in the Jhang and other districts, where tracts of waste land are covered with the wild '*ber*.'"

182. Having given a statement of the process of formation of lac and lac-dye, etc., Mr. Baden-Powell remarks: "About the end of March the lac resin exudation is complete, and the female insects within are glued down by it to the tree. The oval body of the insect becomes of a deep red colour; if at this stage a little piece on the lac incrustation a twig is broken off, the insect is perceived, as a little bag of red liquid (which yields the dye), and the place where the wood of the twig has been punctured bears a snow-white mark, as if the place had been touched with a point of chalk. I have removed an entire piece of lac incrustation from the twig, and observed the bark underneath covered with these little white dots, one in every cell and one under every insect; under the microscope they clearly appear to be specks of a semi-crystalline saline efflorescence, at the place punctured by the insect. The proper stage to collect the lac (if intended to produce dye) is when the insect is in the stage of being like a soft red sac. At a later stage it lays its eggs under its body, which is glued down by the resin; when therefore the eggs are hatched, they have no means of egress save by eating through the body of the mother, which they do, feeding the while on the red colouring matter contained in her body which is thus consumed. When the young insects have regularly eaten through the

* This work was written as a Catalogue of the Lahore Exhibition of 1868.

CULTIVATION IN THE PUNJAB.

mother's body (who of course dies under the operation) they pierce the resinous coating and escape. This occurs about the month of June, as soon as the first rain clouds gather, and the lac which is collected after this yields very little colouring matter. Two gatherings are usual, however, one about March and one in October, or rather later, up country."

Terms given to various Stages.

183. "When the lac is first gathered, it is picked off the twigs with the insects and all on it; in this state it is called 'kacha' or 'kham lakh'; this lac is treated with water, and thus the colouring matter is extracted. By this process the concretions of lac get broken up into grains or small fragments, and this forms the 'lakh dana,' or seed-lac; in this state it contains no colouring matter beyond what is indigenous to the resin. The third or clarified kind of lac is called 'chapra lakh,' or shell lac ('chapra,' a shell). Sometimes the seed-lac is merely melted into lump lac, which is used to make bracelets of."

184. Mr. Baden-Powell next gives an interesting communication from the Rev. J. S. Woodside of Kapurthala relative to the lac insect from which the following passages may be abstracted :—

"About three years and half ago, or in October 1860, the Rajah's Oudh Agent sent up a man from Ikanna with about three maunds of the lac, containing the insect." "The Oudh man remained some 18 months at Phugwara and instructed the man now in charge in the science of lac cultivation. He says they took the lac from the vessel in which it came, put it into detached portions, tied up in little bundles of grass." "These bundles were tied to the larger branches of the *dhak* tree, and as the insect appeared, it found its way out from the bundle on to the branch and soon made its way up the smaller branches where it commenced its operations. This was in November. There seems therefore to be *two seasons* for its labours—the cold season and the rainy season,—the one commencing in November and the other in June. The November crop seems complete in February, and the June crop in September. It is not gathered, however, till the insect leaves it for the succeeding season."

Coldstream's account in 1881 A.D.

The next writer of importance on the lac production and trade of the Punjab may be said to be W. Coldstream, Esq., I.C.S. The following review of his opinions may be, therefore, usefully given :—

Passages taken from the Indian Forester, Vol. VI, July 1880 to April 1881, pages 218 and 219, on the Production of Lac in Hoshiarpur District, By* W. Coldstream, Esq., I.C.S., *Deputy Commissioner.

185. "The district of Hoshiarpur lies between the Beas and Sutlej Rivers. Its surface is, roughly speaking, half plain and half occupied by the outlying ranges of the Lower Himálayas, corresponding to the Siwalik ranges east of the Sutlej. It may, therefore, be called a submontane district. Lac is produced in all parts of it, at least in the plains and in the valleys between the hills. It is more abundant in the latter.

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CULTIVATION IN THE PANJAB. (Hoshiarpur District). Quality and food-plant.

"It affects chiefly the *Beri* (**Zizyphus Jujuba**) and *Kikar* (**Acacia arabica**).

"It is found for example, on six species of **Ficus**. The lac produced by the various trees differs in quality. The lac produced on the **Zizyphus** is deemed the best, and next to it comes that produced on *Sirris*, *Kikar* and *Pipal*.

Seasons.

186. "There are two seasons for production,—February to April and July or August. The crops are collected in June and October or November. The same tree is said not to produce two crops in the same year. The autumn or October crop is considered the more valuable of the two.

"The artificial propagation of lac is understood by very few persons, but seems to be occasionally practised. The method adopted is to tie a small branch with the insects on it on the tree which it is desired to affect. The writer has found it very easy to propagate lac on *Beri* trees in this manner. The twigs containing cells of the insect were tied on to the trees in July; shortly after the new swarm appeared and spread over the nearest branches of the tree. There appears, however, to be among the people a great dread of the tree being injuriously affected by the spread of lac upon it, and this is probably the reason why propagation is not carried on to a greater extent. In cutting lac off a tree, a few twigs containing cells are allowed to remain to furnish a crop for next year.

Injury to Trees.

Objections to the Trade.

187. "There existed a deep and widespread prejudice among Hindus against having anything to do with lac. This was particularly strong among the Bhabras (called in other districts Saraogis). Lac was considered a kind of disease or leprosy of the tree, and to be an unclean substance. Its red colour and its animal origin are sufficient to account for this prejudice. It has disappeared, to a great extent, within the last ten years, owing to the great value which lac acquired in the market. There have been, of recent years, many disputes in the Civil Courts as to the relative rights of landlords and occupancy tenants to take the lac from trees growing in an estate. The question was not discussed at the time of the Revenue Settlement of the district in 1852, lac having then but a small marketable value.

188. "The crop of lac on roadside trees is sometimes sold by Government to a contractor, who is allowed to cut off twigs and branches of a certain thickness. In 1876 the lac on the roadside trees in Unah Pergunnah was sold for more than R400. The crop, however, varies much in quantity from year to year, as does also the value of lac in the market."

Gurdaspur (District).

189. Lac in the Gurdaspur district in thus described. "Of lac in the district there is abundance. It appears chiefly on the *sirris* and *beri* tree, the insect in the course of time ruining the tree. A great deal of lac is collected during the months of January and February in the Barion Bagh near Dinanagar, and as much as R450 to R500 a year is paid to Sirdár Diál Singh of Majitha, who is the Manager of this common on behalf of the towns people. The trees are lopped, and the branches, after the leaves have been beaten off for fodder, are collected and the lac scraped off. This is boiled and purified

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CULTIVATION IN THE BOMBAY.

until it has been brought into a marketable state."—(*Punjab Gazetteer, Gurdaspur District, 1891-92, page 120.*)

Bombay and Sind.

CULTIVATION IN BOMBAY.

190. ***Bombay.***—Very little can be learned regarding the lac trade of Bombay and Sind. As already remarked (paragraph 3), the "gum-lac" of the East India Company would appear to have been very largely obtained from Western India. Where that came from is difficult to understand since at the present day Bombay draws its supplies mainly from the North-Western Provinces and Oudh, both of stick-lac and shell-lac. Of the former the Rail-borne Trade Reports show an annual supply of a little over 1,000 maunds carried by rail to the Bombay Presidency.

191. The Gazetteers, Administration and Forest Reports, say practically nothing regarding lac. The following passage may, however, be here quoted :—

Kaira and Panch Mahals.—"The only industry of special interest is in Dobad. The Lac is produced in small quantities in Dobad and largely in the forests of the neighbouring States of Ali Rajpur, Udepur, and Devgad Bariya. The chief Lac-yielding trees are the *Pipla* (**Ficus religiosa**), the *Khakhra* (**Butea frondosa**), the *Bordi* (**Zizyphus Jujuba**), and the *Kusamb* (**Schleichera trijuga**.)

"The lac is collected by Bhils and Naikdus, who, either for grain or cash, sell it to the Bohora or Vania grain-dealers, at from 1*d.* to 1¼*d.* a pound (R1-8 to R2 a *maund*), who in turn sell it to town traders, almost all Musalmans of the Shia or Dandi Bobora sect. When it comes to the traders, the lac is in a raw state sticking to bark and twigs. To separate the lac from the wood the whole is pounded with stones and winnowed. In this state the powder lac, *Kanja*, is stored; its price in ordinary years varying from 10*s.* to 16*s.* for 40 lbs. (R5 to R8 a *maund*), the cheapest coming from the *pipla*, *khakhra*, and *bordi*, and the dearest from the *kusamb* trees. Of the whole supply only a little is locally worked up into lac bracelets. Of the rest in ordinary years about 5 tons (280 *maunds*) go to Ahmedabad and 7½ tons (400 *maunds*) to Ratlam. In Ahmedabad the lac is used for colouring leather, and in Ratlam for making bracelets.—(*Bombay Gazetteer, Vol. III., Kaira and Panch Mahals, 1879, page 249.*)

Pounded with Stones.

CULTIVATION IN SIND.

192. ***Lac in Sind.***—A useful paper has been communicated by Mr. G. M. Ryan, Deputy Conservator of Forests, dated Karachi, 18th July 1896. A few passages may be usefully abstracted in this place :—

Trees on which Lac is found.—"*Babul* (**Acacia arabica**), *Kandi* (**Prosopis spicigera**), *bar* (**Zizyphus Jujuba**), *sirus*

CULTIVATION IN SIND.

Trees on which found.

(**Albizzia Lebbek**), *banyan* (**Ficus bengalensis**), *tamarisks* (**Tamarix gallica**) are the trees on which Lac may be seen in the Province. Most of it, however, is collected from the *babul* which grows gregariously along the Indus, forming dense forests. *Kandi* in places is also gregarious, but the insect does not usually affect this tree under such conditions. On *Kandi*, it is found about 12 to 14 miles south of Hyderabad along the left bank of the Fuleli, chiefly where the two species *kandi* and *babul* are mixed, and occasionally in the Khipra Taluka in Thar and Parkar. The insect does not appear to be known on this tree at all north of Hyderabad. On *ber*, *sirus* and *banyan*, it is seen mostly along road-sides and banks and canal banks. There is one *banyan* just below the Hyderabad Gymkhana on the road-side which bears a splendid crop every cold weather."

Crops.

193. *Crops of Lac.*—"There are two seasons for gathering Lac, one being in the cold weather and the other in the hot. The cold weather crop is commenced to be gathered when the northerly winds set in in November, and the gathering continues till January or February. The hot weather harvesting of the crop begins with the setting in of the south-westerly breezes in April and lasts till June. The latter, though not so plentiful, is a better crop in value than the former, realising as much as R5 per maund more. The crop on the *banyan* (**Ficus bengalensis**), however, is an exception. Its cold weather crop is both more plentiful and valuable than the summer crop. In order to secure a supply of Lac for the following year, some of the incrustation, containing of course the live insects not yet fully developed, is left on the branches of the trees at the time of gathering. The period when the insect is likely to be ready for swarming out of the incrustation is well known to the gatherers, and about a month or so before this most of the produce is collected, while the remainder is left behind on the branches to form a nucleus for the succeeding crop. Those insects left on the trees swarm out and cover the tender branches in January and July for the two crops, respectively."

Hot weather crop superior.

Except in the case of Banyan.

Method of Propagation.

194. *Cultivation of Lac.*—"It is during these months that it is possible to extend the area under Lac by artificial means. Small branches, covered with the incrustation are cut off and transferred to tender and succulent branches of other trees, in perhaps a totally different locality where Lac does not exist. In making the transfer, care has to be taken to place the cut off branches, bearing the incrustation, on the crowns of the tree intended to bear Lac, in order that as soon as the young brood swarm out they may find young and tender shoots to attach themselves to and may not all drop off on to the ground."

Lac collected long after swarming.

"In consequence of the increased value of the summer crop, and in order to secure a more plentiful supply then, a larger proportion of the incrustation is often left on the trees in the cold weather than is gathered, which was the case this year (1896)."

Yield per tree.

195. *Amount of Lac collected.*—"In the forests north of Hyderabad, each *babul* tree, it is computed, yields 7 to 15 sérs. The trees

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on which the insect is found are of all sizes, varying from 1 to 6 or 8 feet in girth; but the insects confine themselves to the young and tender branches only of the trees. One can generally tell a Lac-bearing tract, because of the ground underneath each tree being strewn with cut-away branches, the Lac from which has been removed."

Relative yield of trees.

"The *banyan* yields the largest quantity of Lac, one to two maunds per tree, *sirus* gives one to one and a half maunds, and *ber* about the same as *babul*, namely, 7 to 15 sérs. It is only in the Sekhat Forest, a tract about 20 miles north of Hyderabad, that Lac is seen on *tamarisk*."

Mr. Ryan then continues:—

No Pests.

196 *Injuries to Lac.*—"Fortunately, there are no insects in Sind which attack and destroy the Lac, as in other parts of India: the only injury to which it is exposed being climatic."

Favourable climatic conditions.

"If the rainfall is above the average, as in 1894 (*viz.*, 10 26 inches in Hyderabad), and if floods in the Indus at the same time are *very* heavy, the excessive moisture in the soil and atmosphere brought about by these conditions affect the crop somewhat injuriously. A moderately moist season seems the most favourable for the propagation of the insect. But conditions are so very unsettled, owing to the vagaries of the river caused by the present embankment system, that no seasons scarcely are now alike. A contractor, who makes a large profit in one year and who pays Government a better price for the next season's crop in expectation of another good crop, probably loses a large quantity of his preceding profits by a failure of the subsequent crop."

Profit.

197. *Will Lac Cultivation Pay.*—"This is not a difficult question to answer, for knowing the area actually covered by Lac and having the value realised from the farm annually, it becomes a simple arithmetical calculation. The area under Lac in the forests of the Hyderabad Division is estimated at 2,000 acres, and the value realised in 1895-96 is R7,560, which gives a net return of R3-12-0 per acre, or more than timber and firewood or cultivation."

"It would be advisable under the circumstances to cultivate Lac, and to set apart a certain area in each forest for maintaining an annual supply, and when it is found that the firewood and timber demand can be fairly met, the area under Lac might further be augmented."

Injury to Trees little appreciable in Sind.

198. "In the Jerruck Division the Lac-bearing area has been excluded from the working plan, and the same arrangement might be adopted for Hyderabad as well as forests in the Thar and Parkar District. It is a mistake to suppose that the depredations of the insect in Sind damage the tree on which it subsists to any appreciable extent. This would be the case probably in a region where the rainfall was moderate, and where forest growth owed its existence to rain; all or a very great deal of the life blood, *i.e.*, sap, would soon be extracted by the multitude of insects on the branches in such localities, and in time the tree would possibly succumb. In Sind, however, there is so much

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moisture in the sub-soil, in the riverain reserves especially, that the *babul*, in spite of the tax which it has to pay in the shape of extraction of sap, and constant lopping of small branches, does not seem to be much injuriously affected. Most of the Lac-bearing trees are useless for timber, but they are nevertheless very huge, being 6 to 8 feet in girth with a splendid leaf canopy. There are forests in the Hyderabad District which have been yielding large supplies of Lac for the past 28 years and more without any apparent injury to them."

Madras, Mysore and Coorg.

CULTIVATION IN MYSORE AND COORG.

199. Lac is comparatively little produced in South India* and the industry of ornamentation with that product is but imperfectly understood, except in one or two isolated localities. One of the earliest and to this day perhaps the most complete account of lac in this Presidency is that written by Dr. Buchanan-Hamilton a hundred years ago. The following passage may, therefore, be reproduced :—

Buchanan-Hamilton's account in A D. 1800.

Passages taken from " A Journey from Madras through the countries of Mysore, Canara and Malabar, by Francis Buchanan, Esq., M.D.," ***(Buchanan-Hamilton), Volume I, page 238, July 17th, 1800.***

200. " The people who manage the Lac insect, in the hills near *Nandidurga*, are of the caste called *Woddaru ;* and for the exclusive use of the trees they pay a rent to Government. The tree on which the insect feeds is the *Jala*, which is nearly related to the *Saul* of Bengal, or the *Shorea* of Gaertner, and perhaps the Vatica chinensis of *Linnaeus.*† All the trees that I saw here were small, not exceeding eight or ten feet in height ; and their growth was kept down by the insect and its managers ; for this size answers best. The tree, left to itself, grows to a large size and is good timber. For feeding the insect, it thrives very well in a dry barren soil ; and it is not planted, but allowed to spring up spontaneously as nature directs. It is often choked by other trees, and destroyed by bamboos, which, by rubbing one against another, in this arid region, frequently take fire, and lay waste the neighbouring woods. By removing all other trees from the places where the *Jala* naturally grows, and perhaps by planting a few trees on some other hills, and protecting them from being choked as they gradually propagate themselves, the Lac insect might be raised to any extent on lands now totally useless, and never capable of being rendered

* Madras Manual of Administration, Volume I., 1885, page 314.
† This is Shorea Talura, *Roxb.*, which Mr. J. Cameron in his " Forest Trees of Mysore and Coorg " calls The Lac Tree or *Jalari*.—G. WATT.

CULTIVATION IN MYSORE AND COORG.

arable. In *Kartika*, or from about the middle of October to the middle of November, the Lac is ripe. At that time it surrounds almost every small branch of the trees, and destroys almost every leaf. The branches intended for sale are then cut off, spread out on mats, and dried in the shade. A tree or two that are fullest of the insects, are preserved to propagate the breed; and of these a small branch is tied to every tree in the month *Chaitra*, or from about the middle of March to the middle of April; at which time the trees again shoot out young branches and leaves. The Lac dried on the sticks is sold to the merchants of Balahari, Gutti, Bangalore, etc.; and according to the quantity raised, and to the demand varies in price, from 5 to 20 *Fanams a maund*. This is what is called *stick-lac*. In my account of Bangalore, I have given the process for dyeing with the substance, which, after the dye has been extracted, is formed into *seed* and *shell-lac*."

201. The account given in the Gazetteer of Mysore and Coorg (*published 1877, page 164*) is an abbreviated version of **Dr. Buchanan-Hamilton's** paper and need not, therefore, be given here. But **Mr. J. Cameron** in his *Forest Trees of Mysore and Coorg* (*published 1894*) furnishes interesting particulars which may be regarded as bringing our knowledge of the lac production and trade down to a recent date. **Mr. Cameron's** remarks will be found under **Shorea Talura,** page 22, as follows:—

J. Cameron's remarks on Lac in Mysore.

202. "The Lac tree of Mysore confined to the deciduous tracts of the maidan. Abundant in the Anekal, Closepet, and Nundydroog Taluks, where the propagation of lac has been actively taken up by the Forest Department. In the first named Taluk, **Mr. Bapu Rao**, the Assistant Conservator of Forests, Bangalore District, is extending the propagation of both the tree and the insect very rapidly. Lac being in great demand, this action cannot fail, in the course of a few years, to largely increase forest revenue. The method of propagation is to fasten small bundles of twigs, with young insects upon them, on to the upper limbs and branches of the unaffected trees."

Burma.

CULTIVATION IN BURMA.

203. In the introductory chapter (paragraph 2) it will be seen that a quotation has been given from **John Huyghen van Linschoten's** account of his explorations in the East (1596 A.D.) in which a reference occurs to the lac obtained from Burma. "The men of Pegu," he says, "(where the best is found, and most trafiqued withall) doe call it Treck,* and deale much therewith by carrying it into

* Is the word *Treck* here given the same as the modern Burmese name Cheik? —*G. Watt.*

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CULTIVATION IN BURMA.

the Island of Sumatra." Balfour and other writers of half a century ago refer in special terms of commendation to the lac of the Shan States and of Siam. It is thus curious that on passing down to modern times practically nothing of a definite nature is known of the lac of Burma. In passing I would remind the reader that it is necessary to be careful to distinguish lac from lacquer when speaking of Burma. The art of producing the latter has been carried to a great state of perfection in that province, but as the chief ingredient in lacquer is a vegetable oleo-resin obtained from **Melanorrhœa usitata**—the *thissi*—it is essentially a different art from that where the animal resin lac—*Cheik*—is employed. That Linschoten had not made this mistake is evident from his careful description of the incrustation on the trees—a substance which he adds is purified, melted and coloured as desired before use. It would thus almost seem as if the lac trade of Pegu some 300 years ago had been very much more valuable to the province than it is at the present time.

Lacquer and lac must not be confused.

204. With these introductory observations the course followed in dealing with other provinces may now be pursued in the case of Burma, *viz.*, to give a selection of passages of an instructive nature from the chief books and official correspondence available :—

Passages taken from the revised edition (by* Theobald) *of Mason's Burma, its People and Productions, Vol. I., page 37.

Account in Mason's Burma.

205. "The lac insect is the most important member of this family. The male has two wings, and flies freely ; but the female is apterous and parasitical (so to say) at all ages. The body is a mass of red-coloured paste, which is simply the lac-dye of commerce, and from the sides of her body exudes a resin in such quantities as gradually to encase her in a sort of cell; this resin is the 'shell-lac' of commerce. The crude lac, as brought to market, consists of the twigs whereon the resinous cells are attached, in which the female lac insects are contained. The whole mass is pounded up and steeped in water, which dissolves out the coloured matter formed of the insect's body. This is subsequently precipitated and formed into cakes, after which the refuse is heated, and the resin melted out. This process is conducted in canvas bags, which are subjected to pressure, and the pure resin as it exudes is scraped off in flakes which are termed 'shell-lac' being faintly orange-tinged. Dr. Mason says—"The Karens think the lac is produced by an ant, and call it the lac ant." The insect is parasitical on several species of trees

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as **Ficus religiosa** and other figs, **Butea frondosa**, **Zizyphus Jujuba**, etc., and is sometimes so crowded on the stems that they are seen incrusted, as it were, with pipe-like mass half an inch in diameter or more, made up of the closely-packed cells of the 'lac insect.' The finest 'lac' comes from Siam and the Shan States *viâ* Rangoon, and much is also collected in Assam and some parts of Bengal."

Mason specially states in his original work that "lac is not formed extensively in the British Provinces of Burma though very abundant in the Shan States adjoining."

Extract from the British Burma Gazetteer, Vol. I., 1880, page 415.

Trial of lac.

206. "*Lac.*—Though lac appears amongst the exportation from the province, and in no small quantities (1.335 cwt. in 1877-78), yet by far the greater portion of this is imported from Burma and the Shan States. In 1874 the Forest Department commenced the cultivation and imported insects from the north, and in 1876 the lac nurseries at Ma-ga-ree near Rangoon were formally declared to have been successful, but the success was short-lived. The principal market is Calcutta."

Copy of letter, dated the 26th June 1894, from the Conservator of Forests, Western Circle, Burma, to the Inspector General of Forests.

207. "With reference to your demi-official Circular No. 1, dated 3rd January 1894, on the subject of lac, I have now received answers from my Divisional Officers to whom reference was made on the subject, but they all say that so far practically nothing is done in Lac in this Circle.

Price.

"The only people who have been in any way connected with this industry are some Chins in Laungshe township, Yaw Division, and 600 viss (of 3·65 lbs.) or about 19½ cwt. have been brought out this year, which sold for R55 per 100 viss (about R17 per cwt.) at Sinbyngym and Minbu."

Copy of letter No. 1677-3E-3, dated the 26th September 1896, from Mr. A. Smythies, B.A., *Officiating Conservator of Forests, Western Circle, Upper Burma, Mandalay, to the Inspector General of Forests.*

208. "With reference to your No. 2213—170, dated 20th July 1896, on the subject of lac, I have the honour to inform you that a

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few more particulars can be added to the demi-official letter, dated the 26th June 1894, but nothing of any real importance.

"The Forest Officer in the Upper Chindwin writes as follows:—

"The only lac industry that I have heard of in this Division is that in the Pinbon Circle, Banmauk Sub-Division of the Katha District.

Destruction of Trees.

"The forest from which the lac is brought is at the head waters of the Chaungyi Chaung which rises between the Kalat and Saitepha Hills; it is a stretch consisting of *Ingyin Tamalan* (**Dalbergia Oliveri**), *Taungthabye* and *Thabyegyi* (**Eugenia sp.**) trees mixed with Bamboos. The hills on which the lac insect is found are known as the Thandaung and Pedaingdaung. Every year in the months of Thadingyut, Tazaungmon and Nadaw the villagers of the Pinbon Circle proceed into the forest to collect the lac, felling trees and breaking off branches to get at it; the usual outturn is from 100 to 300 viss, but every 4 or 5 years the lac insect swarms and the outturn rises to about 2,000 viss. The lac is brought to Pinbon and sold to traders at the rate of 25 per 100 viss, delivered free at Hmegon on the Maze about 12 daings from Pinbon. The villagers pay duly at Pinbon to the Mausi Forester 12½ per cent. *ad valorem.*

Price.

"A little of this lac is sometimes brought into Tammu *viâ* the Chindwin where it is sold for dyeing cloth.

Supply.

"The Forest Officer in the Yaw Division reports that about 1,000 viss (1 viss = 3·65 lbs.) of lac was brought to Monywa during the year where it is sold for R25 per 100 viss; the middleman's profit is about R45 per 1,000 viss; the lac is collected from the end of September to the end of February, and it is found on **Shorea obtusa** and **Shorea siamensis.**"

Extract from the Diary of* Mr. R. M. Kavanagh, *Extra Assistant Conservator of Forests, for the week ending 30th February 1897, forwarded by the Officiating Conservator of Forests, Western Circle, Upper Burma, Mandalay.

Lac in Burma ruinously worked.

209. "The Thandung range has forests of a similar nature with a little teak here and there, and wherever *Ingyin* (**Dipterocarpus tuberculatus**) forests appear the lac insect propagates itself.

"The present mode of extraction is in my opinion ruinous, for the custom is as follows:—

"The villagers of Pembone, Shehhgih Tit-tonc, Tache, when they hear that lac is more or less plentiful, up they come and cut off branches, leaves, etc., and take all they can get, so that after they have left there is little or nothing remaining; whatever has been left by chance takes fully four years to repropagate itself, so that Government only gets revenue to any extent, once in four years; were this area reserved and the insect propagated artificially as well as naturally and the area

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divided into block by block under a fixed rotation, Government would get a steady annual income."

CULTIVATION IN BURMA. (Eastern Circle).

Copy of letter No. 707-47 A., dated the 28th June 1894, from the Officiating Conservator of Forests, Eastern Circle, Upper Burma, to the Inspector General of Forests to the Government of India.

210. "With reference to your demi-official Circular No. 1, dated 3rd January 1894, I have the honour to report that lac is said to be largely exported from Western Karenni. The Deputy Conservator of Forests, Southern Shan States, has not been able to visit that part of the country this year, so is not prepared at present to give any detailed information in regard to the lac industry there.

"The only other tract of country where lac is reported to be common is the Pyinulwin Sub-Division of the Mandalay District, and the adjoining plateau of Thowza and Kalagwe in Hsibaw State.

Decrease of export.

"From this tract it is reported about 70,000 pounds were exported through Maymyo in 1890, and the quantity has steadily decreased to about 60,000 pounds, the quantity exported last year.

Hort. plants.

"In this tract it is collected chiefly from the smooth leaved species of **Ficus**, such as **F. religiosa, F. Rumphii**, etc., from the *Yindaik* (**Dalbergia cultrata**) and *Yindaikpyn* (**Dalbergia sp.**) which are common in the Shan plateau. It is also collected, though not to a large extent, from the *Pankbin* (**Butea frondosa**).

"It fetches from R7 to R8 per 100 lbs. in Maymyo and R9 to R10 in Mandalay.

"No attempt is made to foster its propagation and the collection is carried on in a haphazard way. In the rains, when the crops have been sown and there is nothing particular doing in the taungyas, the men go out to collect. Only a small number of persons are engaged in the business. In a village of 10 houses not perhaps more than 1 to 2 men. They say it does not pay them to go in for the work regularly, and that they merely collect it to supplement the returns from their taungyas. Near Thibaw Mr. Copeland saw a good many **Ficus** trees on the roadside with lac, which apparently no one took the trouble to collect.

"It will be seen that the information received so far goes to show that there is no great field for extending the trade in lac, as far as this Circle is concerned."

211. The most recent writer on Burma, *viz.*, Mr. M. Ferrars, gives lac the name of *Cheik*, but he speaks of it as brought into the province by the Shan traders. He gives full particulars of the Burmese lacquer trade, but makes no mention of lac industries. From this circumstance it may be inferred that lac is very little understood in

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Burma though it is probable a highly lucrative trade might be organised in the product.

Revenue realized on lac from State Forests.

1. *Bengal.*—The statement given below shows the quantity of lac removed from the Reserve and protected forests in Bengal and the revenue realized thereon during the last five years recorded in the Conservator's office. REVENUE FROM LAC IN STATE FORESTS OF BENGAL.

Years.	Reserved forests.		Protected forests.		Total.	
	Quantity	Value.	Quantity.	Value.	Quantity.	Value.
	Mds.	R	Mds.	R	Mds.	R
1894-95	97	170	7	11	104	181
1895 96	164	256	200	125	364	381
1896 97	156	331	...	...	156	331
1897-98	282	341	95	60	377	401
1898-19	58	100	166	110	224	210
Total	757	1,198	468	306	1,225	1,504

2. *Assam.*—Mr. J. A. McKee, the Conservator of Forests, believes that the lac exported from Assam is nearly all collected from cultivated crops of *Cajanus indicus* and gives the following statement showing the revenue realized from Government forests on lac-mahal during the five years 1894-95 to 1898-99:— REVENUE FROM LAC IN STATE FORESTS OF ASSAM.

Year.	Revenue from lac-mahal.	Revenue by sale of lac.	Remarks.
	R	R	
1894-95	54	...	
1895-96	62	4*	* By sale of 20 seers.
1896-97	17	...	
1897-98	...	...	
1898-99	...	...	
Total	133	4	

3. *North-Western Provinces and Oudh, Oudh Circle*—The Conservator of Forests, Oudh Circle, reported that the revenue realized from lac in the several Divisions of his Circle for the years 1894-95, REVENUE FROM LAC IN STATE FORESTS OF OUDH CIRCLE.

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to 1898-99, was as follows: 1894-95, R80, 1895-95, R25, and 1898-99, R295 making up a total of R400 only. There was no revenue realized in 1896-97 and 1897-98.

REVENUE FROM LAC IN STATE FORESTS OF BURMA.

4. *Burma.*—The two Upper Burma Circles and Pegu Circles, Lower Burma, furnished reports that the revenues realized from lac in the Circles are as follows:—

		1894-95.	1895-96.	1896-97.	1897-98.	1898-99.	TOTAL.
		R	R	R	R	R	R
Upper Burma,	Northern Circle	318	757	516	355	207	2,153
	Southern Circle	263	334	292	188	8	1,085
Lower Burma,	Pegu Circle .	321	240	92	26	4	683
	TOTAL .	902	1,331	900	569	219	3,921

Full particulars of the revenue realized in the Northern and Southern Circles, Upper Burma, are given by the Conservators in the following statements:—

Upper Burma. (1) Northern Circle.

(1) Northern Circle, Upper Burma.

Year.	Division.	Lac in viss.	Revenue.	REMARKS.
			R	
1894-95	Bhamo . . .	3,818	286	Actual quantity collected at R7-8 per viss. 16 Licenses, estimated at 100 viss per license at R2.
	Mu . . .	1,600	32	
	TOTAL .	5,418	318	
1895-96	Bhamo . . .	8,771	658	Actual quantity collected at R7-8 per 100 viss. 2 Licenses estimated at 100 viss per license. 41 Licenses estimated at 100 viss per license. Actual quantity collected at R12-8 per 100 viss.
	Katha . . .	200	4	
	Mu . . .	4,100	82	
	Upper Chindwin .	104	13	
	TOTAL .	13,175	757	
1896-97	Bhamo . . .	6,744	506	Actual quantity collected. 1 License estimated at 100 viss. 4 Licenses estimated at 100 viss a license.
	Katha . . .	100	2	
	Mu . . .	400	8	
	TOTAL .	7,244	516	
1897-98 .	Bhamo . . .	4,745	355	Actual number of viss collected at R7-8 per 100 viss.
1898-99 .	Bhamo . . .	4,157	207	Actual number of viss collected at R5 per 100 viss.
	Total of 5 years .	34,739	2,153	

NOTE:—No licenses were issued to collect in reserved forests.

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REVENUE FROM LAC IN STATE FORESTS OF BURMA. (2) Southern Circle.

(2) Southern Circle, Upper Burma. (From July 1894 to June 1899.)

Forest Year.	Divisions.	No. of Licenses.	Revenue.	REMARKS.
			R	
From 1894 to 1895	Minbu	14	28	* Includes 5 Licenses from reserves at 5 per license.
	Yaw	38*	91	
	Mandalay	72	144	
	TOTAL	124	263	
From 1895 to 1896	Minbu	10	20	
	Yaw	59	118	
	Mandalay	98	196	
	TOTAL	167	334	
From 1896 to 1897	Minbu	...	...	
	Yaw	74	148	
	Mandalay	72	144	
	TOTAL	146	292	
From 1897 to 1898	Minbu	...	...	
	Yaw	74	148	
	Mandalay	20	40	
	TOTAL	94	188	
From 1898 to 1899	Minbu	1	2	
	Yaw	...	...	
	Mandalay	3	6	
	TOTAL	4	8	
	GRAND TOTAL	535*	1,085	*535 Licenses at 100 viss each = 53,500 viss.

REMARKS.—In the Yaw and Minbu Divisions lac appears chiefly to come from hill forests not under the control of the Forest Department.

REVENUE FROM LAC IN STATE FORESTS OF THE CENTRAL PROVINCES.

5. *Central Provinces.*—(1) The Conservator of Forests, Southern Circle, reported that the total revenue realized from lac in the Government forests of his Circle during the last 5 years (1895-96 to 1899-1900) amounted to R21,351. He remarked that nearly half this amount was derived from the Raipur district alone, where the right to collect lac is leased out, and it would have been about R4,000 more had no remissions been made. Three Divisions, *viz.*, Bhandara, Nagpur-Wardha, and Sambalpur, showed no revenue at all from this source.

(2) From the Northern Circle R28,984 was realized during the past five years, *viz.*, 1894-95 to 1898-99. The amounts realized from

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REVENUE FROM LAC IN STATE FORESTS OF THE CENTRAL PROVINCES.

the different Divisions during the period is given in the following statement:—

YEAR.	SOLD FROM THE GOVERNMENT FOREST OF THE								
	Mandalay Division.	Jubbulpore Division.	Damoh Division.	Saugor Division.	Narsinghpore Division.	Hoshangabad Division.	Betul Division.	Nimar Division.	Total for Northern Circles.
	R	R	R	R	R	R	R	R	R
1894-95 .	2,102	321	3,150	740	Nil.	532	1,283	Nil.	8,128
1895-96 .	1,146	1,823	2,200	517	275	1,079	1,283	78	8,401
1896-97 .	514	936	1,750	55	300	616	1,283	30	5,484
1897-98 .	432	414	717	33	8	419	440	Nil.	2,463
1898-99 .	1,625	956	767	162	70	385	541	2	4,508
TOTAL .	5,819	4,450	8,584	1,507	653	3,031	4,830	110	28,984

Mr. E. E. Fernandez, the Officiating Conservator, also furnished figures showing the quantity and value of lac exported from the Central Provinces:—

YEAR.	QUANTITY AND VALUE OF LAC EXPORTED FROM CENTRAL PROVINCES.					
	STICK LAC.		SHELLAC.		TOTAL OF BOTH KINDS.	
	Quantity in mds.	Value in R	Quantity in mds.	Value in R	Quantity in mds.	Value in R
1894-95 . .	76,125	19,69,736	1,127	57,477	77,252	20,27,213
1895-96 . .	79,843	20,36,000	1,591	87,903	81,434	21,23,903
1896-97 . .	64,174	10,58,869	2,499	1,30,885	66,673	11,89,754
1897-98 . .	48,686	6,63,347	3,443	1,48,910	52,129	8,12,257
1898-99 . .	38,064	4,80,556	1,649	61,835	39,713	5,42,391
TOTAL .	306,892	62,08,508	10,309	4,87,010	317,201	60,95,518

In his report Mr. Fernandez made the following commentary which is very important:—

"(1) The value of the lac sold from the forests of the circle is almost exclusively the value of leases granted for the right of collection, so that it excludes cost of collection and

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REVENUE FROM LAC IN STATE FORESTS OF THE CENTRAL PROVINCES.

transport to the railway and the profits of the middleman, whereas the figures given for export from the whole Province represent the prices on the railway. For comparison the former figures should be multiplied by at least 6.

(2) A still further allowance has to be made for a fair comparison. The Provincial figures include lac from the Rewah State and Central Province Zamindaris (all of them specially adapted by their climate for the production of lac on a large scale) and from Jagiri and Malguzari-lands. It would not be too much to say that under the most unfavourable circumstances the production from these sources will always be at least eight times that of the Government forest areas.

(3) In consequence of the free concessions granted on account of famine in 1896-97 and 1897-98 lac was almost clean stripped off from all our trees, so that even propagation was rendered extremely difficult. Hence the great falling off after 1895-96.

(4) The climate of Nimar is too dry and hot and that of the greater part of Saugor too cold to be favourable for the production of lac. These two districts contain more than one-fifth of the Government forest area of the Circle.

(5) When all is said and allowed for, the net value of the lac produced in the Government forests of the Circle and paid into the Government treasury should, under the attention which is now being given to the matter and provided meteorological conditions are normal (which has not been the case during the entire quinquennium), reach an average annual figure of R40,000.

(6) Lac is a product the theft of which is extremely easy to effect and as difficult to detect. Without such thefts our receipts from lac would be R60,000 instead of R40,000. It is, therefore, a matter for consideration whether Government should not levy a duty on lac produced elsewhere than in Government forests in order to recoup itself for the thefts committed by private land-owners and those who take on lease the production of private lands in order to be able to steal the lac from surrounding or adjoining Government forests."

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REVENUE FROM LAC IN STATE FORESTS OF BERAR.

6. *Berar.*—The revenue realized on lac from the Government forests in 1894-95 was R1,924, in 1895-96 R1,288, in 1896-97, R866, in 1897-98, R386 and in 1898-99, R467 amounting to the total of R4,931 for the past five years.

REVENUE FROM LAC IN STATE FORESTS OF SIND.

7. *Sind.*— During the past five years the total revenue realized on lac from the forests in the Sind Circle was R34,641. The amounts realized from the three Divisions are shown below :—

YEAR.	REVENUE REALIZED FROM LAC.			
	Hyderabad Division.	Jerruck Division.	Thar and Parkar Division.	TOTAL.
	R	R	R	R
1894-95 . .	8,100	300	77	8,477
1895-96 . .	7,350	367	370	8,087
1896-97 . .	5,410	133	564	6,107
1897-98 . .	8,190	...	645	8,835
1898-99 . .	2,550	...	585	3,135
TOTAL .	31,600	800	2,241	34,641

WHERE STATE FORESTS GET NO REVENUE FROM LAC.

Bombay, Madras and other Circles than those given above reported that no revenue was realized on lac from Government forests. From the reports abstracted above it will be noticed that during the past five years (1894-95 to 1898-99) the amounts realized are, from—

COMPLETE REVENUE.

	R
(1) Bengal	1,504
(2) Assam	137
(3) Oudh	400
(4) Burma (Upper and Lower)	3,921
(5) Central Provinces	50,335
(6) Hyderabad Assigned Districts (Berar) . .	4,931
(7) Sind	34,641
TOTAL for 5 years .	95,869

making a total of R95,869 realized from the Government Forests in India during the past five years. The average for a year calculated from above is R19,173-8, that is, Government get annually less than R20,000 out of an annual export of upwards of R1,40,000.

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MANUFACTURE OF LAC.

CHAPTER IV.

MANUFACTURE OF LAC.

NATIVE LAC FACTORY.

212. ***Native Lac Factory.***—So many persons have written on this subject that it may seem almost superfluous to attempt a new version of so old a story. The twigs with their incrustations of lac are brought from the forest to the factory. They are broken into short lengths—"stick-lac"—by hand or by machinery. This is next crushed either by the ordinary grain-mill, worked by one or two hands (*chakrī* or *jāntā*) or by rollers driven by steam power. The produce is next sifted and assorted by various contrivances, the resulting three substances:—(*a*) fragments of wood (used subsequently as fuel), (*b*) fine dust which consists of dirt and minute fragments of lac known as *khud* (a mixture sold to the makers of bangles, toys, etc.), and lastly granular lac known to the trade as "seed-lac."

WASHING SEED-LAC.

213. *Washing Seed-lac.*—The next stage is to wash the seed-lac. This is done at the smaller native factories by placing the seed-lac within large circular stone troughs and covering it over with water. In this condition it is, as a rule, left for 24 hours. After having soaked to the desired extent a man or woman stands within each trough and (while holding on to a bamboo placed conveniently for that purpose) twists the body this way, and that while pressing every particle of lac, against the roughly hewn surface of the stone trough. As a result the so-called cells of the lac are broken up, the seed-lac being reduced to a smaller and more uniform state of granulation. The water becomes at the same time of a deep purple claret colour. This is the lac-dye or lake which has only to go through certain further stages of manipulation to be reduced to the well-known cakes—the form in which it appears, or, to be more correct, formerly appeared, in the market. In separating the washed lac from the dye a fine powder is obtained, which consists of dirt and minute particles of lac. This, when dried, is sold under the name of *Gaud*, and is like the *Khud* utilised by the manufacturers of lac bracelets.

Bleaching Seed-lac.

214. *Bleaching Seed-lac.*—In some parts of the country, more specially in localities where regular lac factories do not exist but where the artisans prepare the lac required by themselves, a slightly different method of purifying seed-lac prevails. For example, a correspondent in Hoshiarpur in the Panjab sends a description of the process pursued in that district in which the lac is boiled in water

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MANUFACTURE OF LAC.

containing *Sajji* (crude carbonate of soda) and *Suhoga* (borax). This interesting account has been given under Chapter VI. (page 325) and should be consulted.

So, again, from Hala in Hyderabad, Sind, information comes that "the lac, after it is scraped off the trees, gets dried in which state it is purchased and ground in a mill-stone. After which it is washed and purified with potash (*khar*) water. One-quarter of potash to four seers water will suffice to purify 10 seers of lac. It is then dried in the sun." Of Jaisalmer, it is said that the seed-lac is "put in the water of *sajji* and washed by the hand: sometimes it is washed by the water of *lodh* (**Symplocos racemosa**) and borax. The small pieces then become clean." From Jhallawar State it is reported "After the lac has been well rubbed up in water containing a little alum, it is strained through a cloth. Fresh water is then added and treated in the same way until the water ceases to become of a reddish colour."

The question has been raised recently by some of the larger dealers in shellac, whether the Native system of boiling the seed-lac in carbonate of soda did not much more effectually remove the colour and even bleach the lac than the simple trituration method already described. But a further point has also arisen, *viz.*, whether the shellac ultimately prepared from chemically washed and bleached lac is as good as that produced from the lac that has been washed in water only.

Loss of Profit in waste of Dye.

215. *Loss of Profit in Lac Dye.*—It might be almost said that the greatest calamity that has as yet overtaken the lac trade was the discovery of aniline dyes. From being the chief product, lake has declined until it is now of no value whatever. Not many years ago the dye might have been said to represent the manufacturers' profit. At the present day his greatest difficulty is to discover a convenient method of getting rid of this useless bye-product.

Usefulness of Machinery.

By machinery the washing of seed-lac may be more quickly and thoroughly accomplished than by the process briefly indicated as pursued where the lac factory consists of a constant water-supply, a few hand-mills, a stone trough or two and other simple appliances, along with chief labour. But it is perfectly wonderful what can be done with even the most elementary knowledge of mechanical contrivances. In fact it might be almost said that to the present day (in the lac industry) hand labour in one or two directions continues to produce

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results that the highest scientific and engineering skill have failed to accomplish. MANUFACTURE OF LAC.

216. With the washing of the seed-lac the industry was formerly referred to two distinct sections, *viz.*, (*a*) the manufacture of shellac (and all the other forms of the resinous product met with in trade), and (*b*) the preparation of the lake-dye. Although, as already briefly indicated, the latter no longer figures as a commercial article, there is still a small local consumption of the dye. It may, therefore, be convenient to discuss the further stages of manufacture under the sections indicated and to bring together under each of these a selection of the more useful and interesting passages from the published accounts and official correspondence available regarding each of these branches of the trade.

I.—SHELLAC, BUTTON LAC, ETC.

217. In a further passage it will be found that Mr. D. Hooper has been good enough to furnish for this paper the results of his chemical investigations with lac. Although a knowledge of the chemical properties of this substance is essential to the full appreciation of the methods of manufacture, it may be convenient to discuss here the various stages of manufacture usually pursued. MANUFACTURE OF SHELLAC, BUTTON LAC.

After being washed the seed-lac is conveyed to specially prepared drying floors. It is there exposed to the atmosphere and light by which it is thoroughly dried and to some extent bleached.

218. *Mixture of Orpiment and Rosin.*—According to the particular class of manufacture desired lac is now very often mixed with either or both of the following substances, *viz.*, orpiment (or yellow arsenic) and resin. The latter is obtained for the most part from Canada (pine rosin). The former is procured in India and apparently serves mainly (if not entirely) a mechanical purpose. It makes the lac opaque, but at the same time imparts to it a rich pale-straw colour—properties characteristic of all the finer grades of hand-made shellac. Arsenic is not, however, employed in the manufacture of Garnet, Button and the other grades where paleness of colour is not so much demanded. The rosin seems to act the part of lowering the melting point, in many industries a distinct necessity. Its value, therefore, is fully recognised and a certain admixture is not only admissible by the rules of the trade, but few of the shellacs that are regularly Mixture of Orpiment and Rosin.

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MANUFACTURE OF SHELL-LAC, BUTTON LAC.

exported can be said to be entirely free from rosin. Since, however, the price of lac fluctuates very greatly and is in any case much higher than rosin, the temptation is ever present to raise the percentage of rosin mixed with lac. This circumstance may be accepted as one of those that most readily determines the quality and value of lac. During seasons of high prices, the admixture of rosin is often raised until it passes from the condition of permissible admixture to what might be called criminal adulteration. Samples of lac have been examined that contained from 50 to 70 per cent. of Canadian resin instead of the normal 2 to 5 per cent.

The orpiment is ground to a fine powder by the *janta* (double-handed stone-mill) and it is a striking feature of the lac industry to watch this operation. Women, for the most part grind the orpiment, and as often as not they have children alongside of them playing with the blocks of yellow stone or perchance amused by lending their little hands to assist in throwing the stones into the mill. The whole party are literally yellow with the powder produced, and yet it is commouly asserted that no evil consequences are known to be occasioned by this dangerous looking occupation.

219. Referring to the practice of mixing arsenic with lac prior to its being melted into shellac, Mr. E. A. Short of Angelo Brothers recently enquired: "I am anxious to know if there is any substitute for arsenic fusible at or below the temperature corresponding to that of about 35 lbs. of steam power. By the hand method the arsenic fuses into the lac owing to the high temperature of an open fire. We want some substance, giving the same effect of yellow colour and opaqueness, but fusible under the above steam-heating."

Unfortunately the researches conducted at the laboratory connected with the Office of Reporter on Economic Products have as yet failed to discover a substance that could answer the part of orpiment in the shellac trade.

Process of Melting.

220. *Process of Melting.*—After the lac has been carefully mixed with the desired quantity of arsenic or quantities of arsenic and resin, the mixture is packed within very long narrow cloth bags. These are about 2 inches in diameter and perhaps 10 or 20 feet in length. For one class of lac American drill is employed, for another a special cloth made at the Cawnpore Mills, and for a third two bags are necessary one inside the other. After the bags have been charged

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with the lac they are conveyed to the furnace or heating room. For the purpose of melting the lac, long shallow fires of coke or charcoal are employed. These are open in front and are perhaps three feet long, a foot deep, and have an arching masonry roof that completely protects the operator's face from the glare of the fire that he has to keep at a uniform temperature and glow. The bag charged with lac is now drawn along the face of the fire, its weight being carried by bamboo uprights at intervals, while at the far end a short stick has been tied at right angles to the length of the bag. The foreman operator sits on a little raised mud platform to the immediate left of the fire and holds in his left hand the end of the bag. At the other extremity, one of his mates seizes the cross stick and commences to slowly but firmly twist the bag. The heat melts the lac and the squeezing of the bag causes a continuous oozing from the portion exposed to the fire. Every now and again the foreman operator gives his end of the bag a reverse twist which causes the portion from which lac has been expressed to coil round like a rope. Steadily the bag is drawn forward as portion after portion is exhausted. With the right hand the operator wields at intervals three weapons—one a long iron poker which has a wooden handle and a crook-like bend on the further end. With this the fire is every now and again trimmed. Alongside of him is placed an earthen jar full of water. From this, by means of a wooden spoon, he every now and again sprinkles the floor in front of the fire which is so placed as to be a couple of inches below the bottom level of the fire. Over this floor is sometimes put the smooth leaf-sheaths of the plantain stem, at other times the succulent leaves of the American aloe or more frequently still (especially in the more go-ahead factories), polished tiles have been placed. The third weapon used by the master operator is an iron scraper, also furnished with a wooden handle. With this the molten lac, as it oozes from the bag, is scrapped off and let fall on the damp flooring. If not sufficiently cooked, it is again picked up and placed on the bag to be once more melted. At first sight it seems as if any person could assume the rôle of foreman operator to the gang of four or five who constitute the working party at each furnace. But a little more study reveals the fact that there is great skill in knowing when the lac has been cooked (as it is expressed) to the desired extent necessary for the particular manufacture in hand.

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Allotropic change.

221. *Allotropic Change.*—There would almost seem as if the repeated falling on a damp surface and re-melting that ensues had something to say to the peculiar merit of the hand as compared with the machine-made shellac. One might imagine some allotropic or physical change in the lac thus brought about since the skilled operator can tell at once that the lump of lac he hands over to his assistant will possess or will not possess the elasticity necessary to admit of its being stretched to a fineness of tissue paper. Chemistry has so far failed, however, to reveal any direct change as brought about by this dropping of the molten mass on to a damp floor and again and again repeating the process, until the required degree of cooking has been attained.

Stretching Shellac.

222. *Stretching Shellac.*—The next stage in the manufacture of lac is the various methods pursued to stretch the lac into large sheets of the fineness required. In the more primitive factories this is done by placing a lump of molten lac on a plantain stem held at an angle of 60° to the floor. By means of a ribbon obtained from the cocoa-nut palm leaf or from the American aloe the mass of soft lac is pulled out along the plantain stem the operator holding the ribbon firmly in his hands and carrying it deftly along so that the lump of lac is flattened out to a large sheet of uniform thickness throughout. Recently the plantain stem has been substituted by porcelain tubes filled with hot water and more recently still metal pipes of polished zinc. After the lac has been stretched to the utmost possible on the inclined tube it is clipped off at top and bottom and given to a third workman. It is carried off to a little distance in front of the fire where a mat has been placed for that purpose. Seizing the sheet between the toes, hands and teeth this operator stretches it to fully double its former size and then laying it down on the mat (where it looks like a hide stretched to dry) carries it farther and farther from the fire so as to allow each succeeding sheet to cool slowly. The molten lac when handed to this workman is so hot that it would burn the hand dangerously of any person not accustomed to handle it. The practised workman not only holds it firmly and stretches it in all directions in the manner described, but he stands the while within a few feet of the furnace so as to afford the necessary additional temperature to facilitate the stretching.

Forms.

223. *Forms of Manufactured Lac.*—The next stage is to have the sheets minutely examined and all dark coloured or dirt impreg-

nated portions broken out and the balance assorted according to purity and shade of colour—in other words into recognised trade qualities of shellac. The various qualities of shellac are known as "Fine Orange D. C.," "Livery," "Native Leaf," etc. A peculiarity of lac may be here mentioned, namely, that no portion can be regarded as useless. The parings and fragments at every stage of the shellac manufacture are thrown back once more on the floor of the melting furnace and are again melted and made into fresh sheets. But at every stage portions are found that are unsuited for the manufacture of shellac but which are nevertheless quite suited for other industries and find ready enough sale as special forms. For example, certain qualities of lac on being squeezed from the melting bag are allowed to drop on the plantain leaf-sheaths or other smooth surfaces, in circular patches an inch and half in diameter, in order to form the "button-lac" of commerce. Only the finer qualities of seed-lac are, as a rule, made into shellac owing to their paler colour. The more highly coloured lacs are made into thick dark-red sheets, known as "garnet-lac." MANUFACTURE OF SHELL-LAC, BUTTON LAC.

224. *Cleaning the Melting Bags.*—After the melting has been completed the bags are boiled in alkali in order to remove the residuary matter, known as *kiri* or *phog*. From this, two qualities of inferior lac are still procurable, namely, that which is removable from the texture of the bag itself and the other the contents of the bag. These two substances are made into thick circular slabs, perhaps six inches in diameter and an inch in thickness. In this form they are sold to the makers of sealing wax bangles and other such articles. The bags are finally washed, repaired and returned to be used again and again until no longer serviceable. Cleaning the Melting Bags.

225. *Method of Selling Lac.*—By way of concluding this brief sketch of an ordinary native lac factory it may be interesting to mention the manner in which lac transactions are often conducted. The traders sit two and two, the one facing the other. They join hands and place a cloth over the hands, the bargaining being done by a system of symbols in pressing the fingers. Method of Selling Lac.

226. The following passages may be now given from some of the standard works on this subject with a view to amplify what has been stated and to make known the slight local modifications of the system that here and there prevail.

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227. Extract from the Statistical Reporter for 1876, Vol. II., pp. 406-7.

"The manufacture of shell-lac is an entirely distinct process. It has been mentioned above that after the colouring water containing lac-dye in solution has been taken out of the scouring-tubs, the seed-lac, from which the dye has been extracted, remains at the bottom of the tub. This seed-lac, now of a golden-brown colour, is taken to a store room, dried and sifted so as to separate the very small particles known as *malammá*, which would ignite during the process of manufacture into shell-lac. *Malammá* is afterwards sold at R10 per maund to the local *láhirís*, or lac-workers, who make it up into bracelet and ornaments of various kinds. Seed-lac, then, which is to be made into shell, is poured into long bags about two inches in diameter made of American drill, and taken to the shell-lac manufacturing house, a long shed full of small *chulás* or fire-places for burning charcoal. A brass cylinder filled with sand or some heat-absorbing substance, inclined at a slight angle to the ground, is placed within easy reach of each fire-place. A bag full of shell-lac is fixed horizontally on rough trestles before the fire, while a man and a woman, sitting one on each side of the fire-place, twist it tight and keep it turning briskly until the substance of the lac melts and oozes through the interstices of the drill into a shallow trough of aloe leaves placed under the bag. As the mingled resin and wax drop into the trough, the man, while still turning the bag with his left hand, stirs the melted substance in the trough with a wooden ladle, which he holds in the right hand, so as to thoroughly amalgamate the wax and resin. He then lifts a ladleful of this simmering paste on to the cylinder, and spreads it lightly over the upper end. A second woman stands ready here holding in both hands a strip of aloe leaf, with which she draws down the melted lac in a thin coating over the surface of the brass. Directly this is done the man cuts off the upper and lower portions of the sheet with a pair of scissors, and returns these ends, which are too thick for commercial purposes, into the trough of melted lac, where they are worked up again in the next sheet. The woman then takes up the sheet in both hands, stretches it while still supple with the heat in front of the fire, and lays it down as finished. The object of the stretching is partly to reduce the thickness of the sheet and partly to pull out the small wave-like furrows which are impressed on it by the fibrous surface of the aloe leaf. While doing this it is not uncommon to see the Uráon women, who are very intelligent workers, lift the hot sheet to their mouths and bite out any foreign substance, such as dirt or sand, that may appear in the semi-transparent yellow surface. The staff of workers is the same at every fire-place, viz., a man and two women. The average rate of wages is an anna and a quarter per day.

"The hard, brittle sheets, now known as shell-lac, are taken after they have cooled from the manufacturing house to the store-room, where they are broken into small pieces and packed after careful sorting for transport to Calcutta. The refuse left in the bags is taken out at intervals during the process of manufacture and moulded

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by the hand into rough cakes called *kíris* which are sold for local use at R4 per maund. MANUFACTURE OF SHELL-LAC BUTTON LAC, ETC.

"A special variety of shell-lac, very pure in quality but rather darker than the favourite shell-lac of commerce, has usually been produced by the Ranchee Lac Company. This variety is known to the market under the H. S. L. mark, and the Company have recently been engaged on a contract to supply it at the rate of R48 per maund."

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228. *Extract from Bulletin No. 6 of the Agricultural Department of Assam.—A Note on the Lac Industry of Assam, by B. C. Basu, Esq., Assistant Director.*

"Shell and button lac is manufactured in small quantities in Sibsagar and at Mr. Mackenzie's Factory, Rajpur Estate, Cachar. The process of manufacture is the same as followed elsewhere. The crude lac is first crushed and sifted to free it from woody matter. It is then subjected to a long course of alternate washing and drying. until the resin is thoroughly free from colouring matter. The lac, called in this stage *seed-lac,* is then put into a long cloth bag which is held and slowly turned over a charcoal fire. When the resin inside the bag has melted, it is squeezed out by twisting the bag, and is brushed off by drawing it over the smooth surface of a piece of plantain bark. Mr. Mackenzie mixes a small proportion of rosin with the crude lac. In Sibsagar, the lac is washed in alkaline water (*khárpáni*) prepared from the ashes of the plantain tree at one stage of the long course of washing to which it is subjected. Occasionally the residue left in the process of dyeing with crude lac is melted and cast into cakes which are sold along with stick-lac; but they still retain some dyeing matter.

"Another preparation of lac used in Assam is what has been called 'boiled lac' in some of the district reports. In the Assam Valley, it is known as '*Bhiri Laha.*' It is prepared by boiling stick-lac for some hours, until it becomes soft, and then pressing the softened mass into cakes. It, of course, retains the whole of the dye."

229. *Improved Methods with Steam Power.*—When steam power is used the process differs from the every day native factory, mainly in magnitude and rapidity of action. The principles involved and the results attained are almost precisely identical. Improved Methods with Steam Power.

Crude stick-lac is passed between rollers worked by steam. There are usually three sets of these rollers in pairs, an upper and under roller with a sieve attached. The stick-lac passes from a feeder and is crushed by the rollers into "seed-lac" and at the same time separated from the wood by sieves. The broken lac falls from the sieves into a series of small troughs arranged on an endless chain and is projected, as the chain moves, into a heap on the floor.

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The twigs and fragments of wood are thrown off on to a platform on the other side.

The lac is now placed in a horizontal cylinder within which revolves a bar carrying arms, throughout its length. Water is supplied and while the action of the arms breaks the lac into very small pieces, it separates the colouring matter or lac-dye.

230. The washed lac is now thoroughly melted in bags passing through metal jacketed tubes heated by steam, and thence conducted into open shallow troughs, also heated by steam, where the melting continues and the molten mass is thoroughly stirred. When the resin has been thus sufficiently "cooked" it is passed over carefully heated zinc rollers, somewhat similar to those used in making paper, and the sheets of shellac, garnet-lac, etc., by an ingenius contrivance, are caught on bamboo poles and conveyed to a drying room, and ultimately packed in cases for export.

Position of the Lac Trade.

231. ***Position of the Lac Trade.***—Having thus briefly narrated some of the more striking peculiarities of lac factories, it may be useful to give particulars of the extent of the industry of lac-making.

Mr. J. E. O'Conor. (*Financial and Commercial Statistics of British India, 1900*) furnishes the following returns:—

Number of Lac Factories.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
Bengal	34	34	39	34	77	84	99	92	100	95
North-Western Provinces and Oudh	29	25	37	25	24	38	39	41	41	44
TOTAL	63	59	76	59	101	122	138	133	141	139
	PERSONS EMPLOYED.									
Permanent	2,030	2,684	3,002	2,632	3,304	3,814	3,128	3,533	4,073	...
Working season only	805	1,347	1,555	1,565	1,565	1,205	595	553	715	...
TOTAL	2,835	4,031	4,557	4,197	4,869	5,019	3,723	4,086	4,788	7,832
	VALUE OF PRODUCE.									
TOTAL R	167,433	185,740	228,388	211,977	314,963	608,175	389,602	720,422	641,749	494,225

232. It will thus be seen that the lac factories of India, of which returns are available, are located in two provinces, namely, Bengal

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and the North-West Provinces. Further, that a very great expansion has recently taken place in the Bengal interest in this industry. The value of the produce has been returned in tens of rupees and the average for the past three years shows an industry of close on half a million pounds sterling. Although there are no returns of the factories in other provinces of India, it is well known that lac is used up locally to a large extent. Accordingly it might be safe to assume that the statistical returns furnished above very possibly express little more than half the value of the total trade.

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II. Lac Dye.

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233. **Dr. U. C. Dutt**, in his *Materia Medica of the Hindus* (*page 276*), tells us that "the fluid lac-dye obtained by dissolving the crushed stick-lac in water is called *Alakta*. It is used in colouring silk. Cotton coloured with this dye and pressed into flat circular pieces is sold in the bazars under the name of *Alta* and is used in painting the hands and feet of Hindu females." **Dutt's** work was compiled mainly from the Sanskrit authors and may be viewed therefore as expressive of the antiquity of the knowledge in this tinctorial agent. It was due to the desire to discover a cheap substitute for Cochineal as a dye for the uniforms of soldiers that attention of Europe was first drawn to this substance. Although then freely recognised as by no means affording a colour comparable in brilliancy with Cochineal, lac-dye was recognised as being a good serviceable substitute that at least possessed the advantages of cheapness and durability—it is not affected so readily by human perspiration. But when the aniline dyes were discovered a new state of affairs came into operation. Lac-dye, even as a bye-product, cannot compare in price with the coal-tar dyes, and hence where durability is no criterion, lac-dye fell into disuse, and where price is no consideration, Cochineal was naturally preferred. Between these two influences, therefore, lac-dye rapidly ceased to have a commercial position.

234. The process of manufacture of dye varied to some extent in the localities where it was produced according as destined for foreign or local consumption. Since some of the methods stand a chance of being forgotten, it may be desirable to place the more useful particulars on record in this place against the time when a revival of the trade may be called for. It would, indeed, be contrary

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to all modern experience if no use could be found for a bye-product of such ease of production.

Bengal.

235. The following passage from an interesting account that appeared in the *Statistical Reporter* (*Vol. II., page 406*) expresses the system that was pursued about the year 1876 in Ranchee:—

"The process of extracting the dye is somewhat peculiar. A woman stands in each tub on the wet seed-lac, and, steadying herself against the wall with her hands, turns her body violently to the right and left, so as to keep the seed-lac in a continual state of friction against her feet and the sides of the tub. At intervals the tub is filled with water, on which the seed-lac sinks to the bottom, while the dye rises to the surface and is skimmed off in shallow pans. This process is repeated at intervals, until the lac-dye has been completely extracted and the water poured into the tub shows no trace of colour. A full day's work in scouring out the dye is estimated to produce a maund and a quarter (102 lbs.) of seed-lac from which the dye has been extracted. For this an anna and a half is paid. The dye, which is taken up in the form of coloured water from the scouring-tubs, is strained through coarse cloth on a gently sloping platform with a raised edge. Fragments of seed-lac, wood, and dirt that may have been taken up with the water out of the tubs, remain in the straining cloths, and this refuse is subsequently dried and sifted and sold as *pank*, for R3 per maund. The pure colouring matter, still held in solution by the water, runs slowly off the platform through a fine wire sieve, and flows in a slow current, along a gradually descending series of zigzag troughs into a well, the mouth of which is covered with a second sieve of still finer texture. While passing along these channels the sediment that has found its way through the straining cloths falls to the bottom of the troughs, and a further deposit of sediment is left in the well. From the well the coloured water is pumped up into a large vat, and at the end of the day lime-water is poured in to precipitate the dye. By the next morning the dye has settled, and is ready to be run out into boxes lined with cotton cloth and with small holes in their sides. From these the dye is transferred to compressible frames containing strong iron plates, and reduced by screw press to solid sheets of dark purple dye about a quarter of an inch thick. These are cut up into cakes and stored until dry enough for packing."

Passage from J. E. O'Conor's *note on Lac Manufacture, etc., (1876).*

236. A good account of the manufacture in accordance with the ordinary processes is given in the following extract from a paper by Mr. H. A. Crichton, of Ranchee, which was published in the supplement to the *British Burma Gazette* for 11th April 1874:—"The

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grain is first placed under *dekis*, or triturated in some other manner and water is poured or flows over it at the time of trituration, the result being that the colouring matter passes from the grain, which remains of a golden colour, into the water.

"The grain is then dried and stored for making shell-lac. The dye containing water is run off into a vat and allowed to remain there till the dye is precipitated, looking like dark mud at the bottom of the vat. The surface water is then run off, and the precipitate removed from the vat. The water is first expressed by placing the precipitate in cloths and allowing the water to pass away through the cloth. Frames should be prepared, about 18 inches square, having compartments about $1\frac{1}{2}$ inch square; the frames to be fitted with loose tops and bottoms, the whole susceptible of compression. When the muddy matter is tolerably consistent, the compartment should be filled with it and put into a screw press. The water will then be expressed, and when the cake is firm, it may be thrown on a clean floor to dry thoroughly, and will be a cake of lac-dye and fit for the market."

Passages taken from Dr. H. M'Cann's, *Dyes and Tans of Bengal, pages 53–56, 1883, on the subject of Lac.*

237. Space cannot be afforded to reproduce Dr. M'Cann's paper in full. Such passages as give local peculiarities only in the preparation of the dye are therefore given in the passages that follow:— **Dye preparation.**

238. "*Preparation of the dye.*—The following are the methods employed by the native dyers of Bengal for preparing the dye from the crude stick-lac. These may be divided into three stages:—(1) the separation of the resin from the wood round which it forms an incrustation; (2) the separation of the dye contained in this (lac-dye) from the resin (seed-lac); (3) the formation of the dye into solid cakes.

"The first of these objects is obtained by pounding the stick-lac between stones, or grinding it in some way: the resin separates readily from the twigs, which are removed. **Separation of resin from wood.**

"The contained dye is then separated from the resin by pounding the resin into a finer powder and leaving it to soak in pots or troughs of water for periods varying from 6 to 24 hours. Generally after the first trituration the powdered resin is left to soak by itself, but sometimes it is rubbed continually under the water to ensure the complete separation of the dye from the resin, and fresh water is added at intervals. When the dye and the resin are completely separated, the thick liquid containing the dye is strained off through a piece of coarse cloth, leaving the resin (shell-lac) behind. **Extraction of dye from the resin.**

239. "In order to obtain the dye in the form of solid cakes, the liquid thus obtained is simply left to settle in vats, at the bottom of which a thick sediment forms. Sometimes a little *lime-water* or *quicklime* is added to quicken the formation of this sediment; sometimes a series of vats, generally three, one above the other, are employed. The liquid is first run into the upper vat, where a sediment is soon formed; the liquid remaining is then run into the **Formation of dye into cakes.**

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second vat, where another sediment forms more slowly; the liquid from this is then run into the lower vat, where the precipitation of all that remains of the lac-dye is ensured by adding a small quantity of *lime-water* (Birbhum, Manbhum).

240. "The thick sediment thus obtained is then placed in wooden boxes and pressed into the form of cakes. The wooden boxes are sometimes lined with cloth to absorb part of the moisture. The cakes are then dried by exposure to the air and cut into the required size. These cakes constitute the lac-dye of commerce. In some places the dye is made into small balls instead of cakes (Lohardaga).

Preparation of dye from crude stick-lac.

241. "Frequently the dye when required is prepared directly from the crude stick-lack, and not from the cakes of dye. In Maldah the Collector reports that for this purpose the stick-lac is ground, and then left to soak in water for about six hours (or a whole night) in an earthen vessel: about 12 seers of water being used for about 10 seers of the powdered stick-lac. The quantity of water is given as two maunds in another account. The lac powder is then squeezed and rubbed with the hand and 4 or 5 tolas of *sajjimati* are thrown in whilst this is going on, and the whole is sometimes well mixed together by rubbing with the feet. It is then strained and the liquid placed in another earthen vessel and boiled; afterwards 15 tolas of the strained powder of the bark of the *lodh* tree (**Symplocos racemosa,** *Roxb.*) are mixed gradually with it, and it is left to stand for a day. The scum and froth are then skimmed off, and the liquid is strained through a cloth and is ready for use. The liquid dye thus obtained is called *bol.* Sometimes this liquid is further mixed with hot tamarind-water, prepared by mixing 2½ or 3 seers of tamarind with 1 maund of water.

Used as a coasmetic.

242. "Lac-dye seems to be employed in various parts of Bengal by native women as a cosmetic for dyeing the soles of the feet, and the palms of the hand or tips of the fingers, taking the place of mehndi or henna (**Lawsonia alba**) which is almost universally employed for that purpose. To prepare this cosmetic, pieces of stick-lac are bruised in water, and cakes made either of cotton (Murshidabad) or of the similar floss covering the seeds of the *mudar* (**Calotropis gigantea**) are steeped in the water, so that the fibres may attract the dye (Lohardaga). These are the cakes used as cosmetics either by wetting them and rubbing them on the hands and feet, or else by soaking them in water and applying the water to the skin. These cakes are called *alta* (Murshidabad).

European capital.

Decline of lac-dye industry.

243. "As regards European capital invested in the manufacture of lac-dye at the time when this report was compiled, mention was made in the Collector's reports of the following factories:—One in the Birbhum District, that of Messrs. Farquharson & Campbell, of Ilambazar, in which very little capital was invested in the preparation of the dye, the principal business being indigo; several factories at Sonamukhi, in the Budbud Sub-Division of the Burdwan District; the factory of the Ranchi Lac Company at Ranchi, in the Lohardaga District; and two factories at Dacca. In these, however, as well as in the larger factories at Calcutta, less and less attention was being

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given to the preparation of the dye, as it was ceasing to be remunerative owing to the fact that cochineal was rapidly taking its place in Europe and aniline dyes in this country. The reports of the Collectors were nearly unanimous in stating that wherever aniline dyes were known to the natives, they were rapidly superseding lac-dye. The fall in the selling price of lac-dye from about R80 per maund to about R16 in the three or four years preceding 1876 is attributed to the simultaneous introduction of these cheaper mineral dyes." MANUFACTURE OF LAC DYE IN BENGAL.

Extract from a Note by Mr. T. N. Mukharji *on a visit to a Calcutta Lac Factory.*

244. "The lac when broken is next steeped in water in a vat or in a large earthen tub (*Gámlá*), for 24 hours, after which, while still immersed in water, it is trodden by the feet or carefully rubbed with the hand. The red colouring matter adhering to the lac-resin is thus dissolved and washed, for it is prejudicial to the preparation of the shell-lac. The water in which the lac is steeped and washed becomes impregnated with the red colouring matter. This water was formerly boiled * and evaporated, in order to obtain the colouring matter in a dry state, which was made into cakes and sold as 'lac-dye.' At present there is no demand for the lac-dye, and the coloured water is now thrown away, thus turning into a waste product, what was formerly a source of profit. In short, this is the principal cause of the decline of the trade in lac."

Assam.

Extract from Bulletin No. 6 of Department of Agriculture, Assam—A Note on the Lac Industries, B. C. Basu, *Assistant Director.* MANUFACTURE OF LAC-DYE IN ASSAM.

245. "The commercial product known as lac-dye is nowhere prepared now-a-days in Assam. The dye can, however, be easily extracted from crude or boiled lac, and is in every day use in Assam for dyeing cloths and yarns. The following description of the process of lac-dyeing, as practised in Assam, is reproduced from Mr. Duncan's Monograph on Dyes and Dyeing in Assam:—

"Lac furnishes one of the dyes most commonly used in the province, both alone and with other ingredients. Used alone, the process is as follows:—The lac is pounded to a very fine dust. It is then thoroughly washed in warm water by rubbing the particles in the hands. The water assumes a red tint, and when all the colour has been extracted from the dust, the decoction is very carefully strained so as to prevent any of the dust being left in the dyeing fluid. This is to prevent the lac substance, which is sticky, from afterwards adhering to the cloth or other article to be dyed. The fluid so obtained is then boiled, and, when boiling, the cloth (or thread) is put in and allowed to remain until it assumes the required shade. The result is a red.

* No other writer in connection with the province of Bengal appears to mention boiling as necessary. (*Conf. with pp. 292 and 293*).—*G. Watt.*

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This process, which I watched in Jorhat, is typical of the simplest form of use of the insect without other ingredients for dyeing purposes.

246. "The articles usually coloured with lac-dye are cotton cloths and thread of every kind of material (cotton, silk, *muga* or *eri*). The use of the dye in the Assam Valley is confined to the Kacharis, Mikirs and other non-Hindu tribes. The Hindus have a natural aversion for dyes of animal origin."

MANUFACTURE OF LAC-DYE IN THE N.-W. PROVINCES AND OUDH.

North-West Provinces and Oudh.

Extract from the Gazetteer, Vol. XIV (1884), pp. 214-5.

247. "The process of preparing the 'stick-lac' of commerce for exportation is extremely simple; it consists merely in separating the lac from the stick, and dividing it into its component parts of colouring matter and resin. The stick-lac is first roughly ground up, and the stick (which consists of the twigs on which the lac is formed) sifted out. The residue is mixed with water which absorbs the colouring matter. This fluid is run into vats, where the dye precipitates itself. The water is then drained off, and the dye put into presses and made into cakes in which form, when dry, it is exported. After the dye has been absorbed by the water, the residue, which is called 'seed-lac' is cleaned by sifting, filled into long cylindrical bags of cotton cloth (which are turned in front of charcoal furnaces until the lac melts), and then strained or forced through the pores of the cloth by twisting the bags. The lac so strained is stretched over smooth cylinders to the requisite amount of thickness; it then becomes shell-lac, in which form it is exported.

248. "Besides the establishments—at Narghat and Bariaghat—of Messrs. Jardine, Skinner & Co., Messrs. Schoene, Kilburn & Co. have a large factory at Rukhaghat, and there are some score or so of native houses, large and small. The industry probably employs, directly or indirectly, not less than 4,000 people. 'The total capital employed in the manufacture is returned (1881-82) at over 25 lakhs of rupees, and the value of the annual outturn has been calculated to be R16,00,000. Almost four-fifths of the total capital employed is represented by the four factories which are in European or Armenian hands. The industry is said to be suffering severely from the fall in the price of lac-dye which has taken place in late years. (Report on the Railway-borne Traffic of the North-Western Provinces and Oudh for 1881-82, p. 40)."

Passages taken from Mr. Buck's *Dyes and Tans, 1878, pages 24-25.*

Preparation of the dye.

249. "Lac-dye is made from the watery infusion which remains after the trituration and washing of the stick-lac. This is evaporated *

* It will be recollected that Mr. T. N. Mukharji mentions boiling as practised in Bengal. (*Conf. with p. 291*). – *G. Watt.*

to dryness and the residium made into cakes about 2 inches square and half an inch thick.

MANUFACTURE OF LAC-DYE.

Use of lac-dye.

250. "In these provinces lac-dye is chiefly used in dyeing leather, silk and wool. The process followed will be described under the headings allotted to these industries. The dye is prepared for use by being boiled in water; in some places it is merely soaked in water with a little borax. The colours it produces are red, dark-brown, and red-brown."

Central Provinces.

MANUFACTURE OF LAC-DYE IN THE CENTRAL PROVINCES.

Passages taken from Mr. Russel's ***Monograph on Dyeing Industry of the Central Provinces for 1896, page 19.***

251. "Stick-lac is the only form used by the dyers of the Central Provinces. It is gathered by the jungle tribes who break off twigs and small branches on which incrustations have been formed and scrape them off the larger branches. They sell it, as it is gathered, to the Komtis or merchants, who sell it to the dyers. The price is stated to be about R20 per maund. The dyers place it on a board and pound it lightly with an iron rod in order to separate the wood and dirt from the lac incrustation. The lac is then boiled with *lodh* * bark and *datia khar* (carbonate of soda). For a seer of lac eight tolas each of *lodh* bark and *datia khar* are used, and these will be boiled in a gallon of water. After boiling for about two hours, it is taken off and allowed to stand for three days. A sediment has then formed, and the water is then strained off leaving this. The water is mixed with fermented tamarind juice and heated over a fire. When it is hot, the silk thread to be dyed is put into the mixture and boiled in it for about a quarter of an hour, when it becomes thoroughly impregnated with the dye. In Chhindwara to one seer of lac, 5 tolas of alum, 20 tolas of tamarind leaves and a tola of *lodh* bark are added. These ingredients are boiled together in water and the thread is dipped into the mixture and takes the colour. The quantities given are sufficient for four seers of silk thread. The thread costs R12 per seer and a rupee has to be paid for carding it. Material for dyeing costs about 12 annas for a seer of thread, of which the lac counts for 8 annas. The silk is stated to lose one-fourth of its weight in the dyeing process. The cloth woven from a seer of dyed silk costs R20. The silk-dyers state that they do not use aniline dyes owing to their fleeting character, which is naturally a more important point in the case of silk than cotton fabrics owing to their greater value. The manufacture of red silks in these provinces has been affected to a certain degree by the importation of ready woven cloths from Benares. These are stated to be cheaper, but less durable, than the cloths made in the Central Provinces. The silk-weavers say they make about R10 a month if in full work. In Mandla white wool is dyed with lac by the blanket-makers, who ornament their blankets with a stripe or two of red on the edges.

Lac-dye.

* **Symplocos racemosa.**

MANUFACTURE OF LAC-DYE IN THE PANJAB.

In Raipur the *Chamars* use it for colouring the fine leather from which the upper parts of shoes are made. The dyers say that lac is not suitable for dyeing cotton cloth."

Panjab.

Passages taken from Baden-Powell's Hand-book of the Economic Products of the Panjab, Vol. I., pages 193-194.

Lac-dye.

252. "This dye is obtained from lac by treating the crushed lac with water to dissolve the colouring matter; as before observed, it is best that the lac should be gathered when the insect is within the lac concretions. If the lac is not gathered till after the insect has escaped from its resinous envelope, the quantity of colouring matter obtainable is very small."

"The lac-dye of commerce is prepared by evaporating the coloured tincture to dryness, when the residue is formed into little cakes, two inches square and half an inch thick; these are of various qualities and are marked with different letters by which the quality is recognized."

CHAPTER V.

CHEMISTRY.

(By Mr. D. Hooper.)

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253. *Lac.*—The chemical constituents of crude lac have been separated and investigated by various chemists during the past 70 or 80 years. Drs. John and von Undervorben were the first to experiment with this product, and their results, more as a curiosity at the present day than from any real value, have been quoted in all standard works. The latter investigator in 1828 found the crude or stick-lac to contain the following ingredients:—

von Undervorben on the Composition of crude lac.

1. A resin soluble in alcohol and ether. 2. A resin soluble in alcohol, insoluble in either. 3. A resinous body, little soluble in cold alcohol. 4. A crystallisable resin. 5. Wax. 6. The fat of the insect consisting of oleic and stearic acids. 7. A brown extractive, the laccine of Dr. John. 8. A colouring matter.

254. In 1835 Nees von Esenbeck and Cl. Marquart obained from shellac four resins, wax and traces of a dyeing principle. The resins

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were distinguished by their solubility in alcohol, ether and alkalis, and the colour of each when evaporated in a pure condition.

Tschirch and Farner's analysis.

255. The most recent and complete analysis of stick-lac has been made by A. Tschirch and A. Farner (*Arch. Pharm.*, 1899, 237, 35). The proportion in which the chief constituents exist is shown in the following table:—

Pure resin	74·5	{ Ether insoluble . . 65 Ether soluble . . 35
Colouring matter	6·5	Schmidt's laccaic acid.
Wax	6·0	
Residue	9·5	Sand, wood, insect remains, etc.
Moisture	3·5	
	100·0	

Aleuritic acid.

256. The resinous principles were minutely examined during the course of this investigation. After the removal of the wax by means of light petroleum, and that of the red colouring matter with hot water, the resin was dissolved in hot alcohol, and filtered into water. The purified resin formed a bulky, amorphous, light-brown powder, devoid of acid properties. The portion insoluble in ether yielded aleuritic acid and resino-tannol, which might be regarded as the resino-tannol salt of aleuritic acid. Stick-lac in this respect resembles amber in the fact that its resin contains fatty acids; all other resins, such as colophony, contain only aromatic acids. The original lac resin soluble in ether afforded a substance named erythrolaccin. This body is of a fine yellow colour, crystallises in golden-yellow spangles, sublimes in red needles, and is soluble in alcohol, ether, benzol, toluol and chloroform with a golden-yellow colour; in alkaline solutions it assumes a fine violet colour.

Erythrolaccin.

257. In the process of manufacturing stick-lac into seed-lac, the woody impurities and a large portion of the soluble colouring matter are removed, the former by beating and sifting, and the latter by washing in a current of water. The proportion of resinous matter consequently is increased to a considerable extent. In the next stage of the process where the seed lac is melted and strained while hot through canvas bags, further purification ensues, and the resinous matter is converted into the form of button or shellac, as required by the manufacturer.

258. The composition of the three chief commercial forms of lac is instructively represented in the following table of analyses made by

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Mr Hatchett, where it will be seen that the colouring matter decreases and the resin increases in the finished article :—

Comparative analyses.

	Stick.	Seed.	Shellac.
Resin	68·0	88·5	90·9
Colouring matter	10·0	2.5	·5
Wax	6·0	4·5	4·0
Gluten	5·5	2·0	2·8
Impurities	10·5	2·5	1·8
	100·0	100·0	100·0

259. To further illustrate the difference in the composition of lac grain, prepared by breaking up, sifting and washing the crude lac, a series of six samples of Assam seed and dust were submitted for analysis by a firm of manufacturers near Calcutta. It was desirable to know what proportions of dye and impurities were present in each sample. It had been found by experience that the smallest grain produced the darkest lac, and it was suspected that the larger grains contained very few substances besides pure lac and lac-dye, while the smaller particles contained more extraneous matter.

Experiments with Assam sample.

260. The specimens forwarded for analysis had the following distinctive labels :—

1. Assam Large Seed Lac . . . . (11777-5).
2. Assam Clean Lac (not washed) . . (11777-3).
3. Assam Small Seed Lac . . . . (11777-4).
4. Khood (not washed) . . . . (12091).
5. Dust, Sifted from Stick Lac (not washed) . (12090).
6. Gaud (refuse after washing) . . . (12090-2).

261. The resinous matters in these samples were extracted by means of alcohol, dried in a water-bath, and weighed. The dry insoluble residue was washed with hot water and again weighed, and the balance was estimated as colouring matter. The ash and moisture determinations were made on the original products. The following figures were thus arrived at :—

	Resin.	Colouring matter.	Insoluble matter.	Ash.	Water.
1	91·5	0·5	4·9	0·5	2·6
2	84·7	3·5	7·6	1·1	3·1
3	93·7	0·4	3·5	0·2	2·2
4	72·0	3·4	17·5	3·3	3·8
5	56·2	9·2	21·1	9·4	4·1
6	56·0	4·9	30·7	2·6	5·8

262. The samples of lac were arranged in the above order, according to the size of the grains. It will be seen that the specimen most free

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from impurities is that labelled "Assam Small Seed Lac." Proceeding down the list, the percentage of resin decreases and the insoluble albuminous matter, the chief deleterious ingredient, gradually rises in proportion. It might be noticed also that the specimens of seed lac retain less moisture and ash than the inferior small-grained samples.

Removal of colouring matter.

263. The colouring matter of these lacs was removed by employing hot water, but a small additional quantity of red pigment is separated by treating the washed residue with an alkaline solution. Alkalis remove a considerable amount of albumen from the insect or puparial remains, so that this method would be unsuitable for determining the colouring matter in analysis. On the other hand, a small amount of alkaline carbonate is advantageous in the removal of colouring matter in manufacture of seed lac. The Native workmen are in the habit of using *sajji-mati* or impure carbonate of soda for this purpose, the proportions being 3 chittacks per maund of seed lac. Used in these proportions and exposed to the sun, the lac becomes partially bleached. Caustic soda, even in dilute solution, attacks and partially dissolves the resins in seed lac, and if the solution is at all concentrated, it entirely dissolves it. The caustic alkali also renders the lac resin less soluable in spirit and make it hard and tough so as to unfit it for successful shellac-manufacture.

Properties of the resin.

264. *Properties of Lac Resin.*—Lac resin has a specific gravity of 1·139. It is soluble in dilute hydrochloric and acetic, but not in sulphuric acid. With the aid of heat it dissolves readily in a solution of borax. It combines with caustic potash, soda and ammonia, with a reddish-brown colour. It is also soluble in solutions of the carbonated alkalis; by passing chlorine gas in excess through the dark-coloured liquid, the lac resin becomes bleached and is precipitated in a colourless state. Lac bleached in this manner must be thoroughly washed in water and should be kept under water to prevent it becoming discoloured. When dried, it gives an excellent white varnish, particularly with the addition of mastic and a little turpentine.

265. A solution of lac resin in carbonated or caustic alkali may be precipitated by the addition of an acid, but the lac appears to undergo some physical alteration by contract with the alkali which renders it unsuitable for shellac manufacture. The recovered lac is tough and dark in colour, and does not admit of being stretched out into sheets.

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Chemical preparation of shellac.

266. In 1843 letters patent were obtained in England by Mr. George Evans for treating the several sorts of crude lacs by a chemical method to convert them into the more useful and saleable shellac of commerce. The native method was quite unsuitable at home where labour is expensive and the habits of the people so widely different, and the absence of the smooth-surfaced, supple and moist plantain leaf is an insuperable barrier to its preparation. The method consisted in dissolving the lac in an alkaline solution and subsequently decomposing it with sulphuric acid; this left the lac in a fairly pure state differing in some of its qualities according to the material from which it was made. The plan succeeded for a short time and considerable quantities were sold in the London market, but regular supplies failing from India, and never being uniform in properties, difficulties arose in the manufacture, and the factory was soon closed at a considerable loss to the originator of the scheme. (*See Journal of the Agri-Horticultural Society of India, Vol. X, Pt. I., Jan. 1857 to June 1859, pages 50-53.*)

Adulteration with rosin.

267. *Adulteration of Shellac.*—The most usual adulterant of shellac is pine resin or rosin, which, on account of many of its properties being similar, is difficult to detect. An experienced dealer may recognise the odour of rosin by breaking the sample in the palm of the hand, but the proportion can only be estimated by the use of solvents or by taking the specific gravity.

Ether and petroleum ether dissolve rosin completely, while they have only a partially solvent action upon lac.

Determination of impurity.

268. Dr. Julius Wiesner has suggested a process for separating these substances based on the difference of their densities. A solution of common salt or sugar is made up to the density of 1·08 to 1·09 at 15°C; resin floats, while shellac falls to the bottom of such a liquid. The sample is finely powdered and shaken briskly with the solution, which is then allowed to stand for some time. The liquid along with the floating resin is decanted, and the deposited shellac is washed and weighed to ascertain the proportion in the mixture.

Bleaching processes.

269. *Bleaching of Shellac.*—Attempts have often been made to bleach shellac and remedy the objectionable colour. Chlorine is often used for this purpose. The lac is dissolved in a weak alkaline lye and a current of chlorine passed through the solution. The gas, however, acts very energetically and often so modifies the resinous

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matter that it becomes almost insoluble in alcohol. Moreover, great trouble is experienced in removing all the chlorine, even after repeated washing with water.

1. *Willstein's Process.*—500 parts of chloride of lime are mixed with 2,000 parts of water, and a solution of 500 parts of carbonate of potash in 1,500 parts of water is run in so long as a precipitate is formed. Into the filtered liquid there is run, a little at a time, a solution of 500 parts of orange shellac in 2,000 parts of alcohol of 90 per cent. It is stirred and allowed to stand in the sunlight for half an hour to an hour. The liquid containing the resin is then run into dilute (1·5) hydrochloric acid, and when precipitated, is washed with water until free from acid.

2. *Another Method.*—The above method is costly owing to the use of alcohol. 40 parts of shellac are heated with a solution of 10 parts of carbonate of soda in 150 parts of water until completely dissolved. To the decanted clear solution is added 40 parts of chloride of lime in 40 parts of water; the whole is left to stand for 24 hours, and then the resin is precipitated by hydrochloric acid as above.

3. *Alkaline Method without Chlorine.*—The shellac is added in small quantities to a dilute solution of boiling soda by taking care not to make a fresh addition until the previous lot has been dissolved. stopping short when there is a slight excess of free soda. The whole is boiled for a few moments with constant stirring, and then allowed to cool. The wax, which solidifies on the surface, is removed, and the clear liquid is treated with hydrochloric acid, as before. The product is not perfectly free of colouring matter.

4. *Elsner's Method.*—Animal charcoal is used in this method, an article which bleaches the resin without altering it. A quantity of coarse-grained animal charcoal is added to the alcoholic solution sufficient to make a fluid paste, and the whole is exposed to sunlight for several days, taking care, however, that the temperature is not too high. When the solution is sufficiently bleached, the whole is thrown on to a filter, and the filtrate is evaporated. The product is remarkably pure, but the process is costly.

5. *Sulphurous Acid Method.*—It has been further proposed to dissolve the shellac in alkaline lye and to neutralise it afterwards with a current of sulphurous acid, which precipitates the bleached shellac. (*From "The Manufacture of Varnishes, Oil Crushing, Refining and Boiling,"* by Ach. Livache).

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Lac-dye.

270. "*Lac Dye.*—The dye in the ordinary course of manufacture is washed away as a red liquid when the stick or seed-lac is broken and cleaned in a current of water. The liquid is allowed to run into vats, a certain amount of lime is added to precipitate the colouring matter, the deposit is then pressed, cut into cakes, and dried." This is the usual method of preparing the dye in India, although other devices are recorded in older works. In **Crooke's** "Hand-book of Dyeing" it is stated that the liquid, "after filtration through coarse canvas, is evaporated in pans placed on a charcoal fire, or left to spontaneous evaporation by the sun's rays in shallow earthenware vessels." This information is obtained from an Indian source, probably from **Baden-Powell's** "Punjab Products." In Spon's "Encyclopædia of Manufactures," it is asserted that the filtered liquor is treated with boiling alum water and run into settling tanks to deposit the colouring matter. Here the formation of a "lake" is contemplated, but lime, and not alum, is ordinarily used as the precipitating agent. **Messrs. Brooke, Simpson and Spiller** introduced into commerce some years ago a lac-dye superior to that imported from India. Their improvement consisted in treating the stick-lac with weak ammonia, and adding to this solution chloride of tin, when a fine red insoluble matter is formed and precipitated. This preparation is chiefly applied for dyeing woollen fabrics scarlet; 2 to 3 parts produce the same effect as 1 part of cochineal.

Preparation.

Composition of dye.

271. *Composition of the Dye.*—The dark purplish cakes of lac-dye are sold in squares of 2 inches (52 millimetres) by ½ inch (13 millimetres). These cakes consist of 10 to 13 per cent. of actual dye, 9 to 11 per cent. of moisture, 15 to 18 per cent. of mineral constituents, and 57 to 68 per cent. of organic matter.

Lacoaic acid.

272. The dye was examined by **Dr. E. Schmidt** in 1887, who separated the colouring matter in a crystalline condition, and named it laccaic acid. This substance crystallises in rhombic plates of a yellowish-red colour, soluble in alcohols, acetone, and acetic acid. Alkalis produce with it a characteristic red colouration.

In many of its chemical properties and its absorption spectrum laccaic acid resembles carminic acid, the active colouring principle of the cochineal insect (**Coccus cacti**).

273. The following account by **Dr. Normandy** describes the application of lac-dye in England:—

"The cakes of lac-dye imported from India, stamped with peculiar marks to designate the different manufacturers (*the best* DT., the

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second JMCR, the third CE), are now employed in England for dyeing scarlet cloth, and are found to yield an equally brilliant colour. When the lac-dye was first introduced, sulphuric acid was the solvent applied to the pulverised cakes, but as muriatic (hydrochloric) acid has been found to answer, it has to a great extent supplanted it. A good *solvent* (No. 1) for this dye-stuff may be prepared by dissolving 3 pounds of tin in 60 pounds of muriatic acid, of specific gravity 1·19. The proper *mordant* for the cloth is made by mixing 27 pounds of muriatic acid of sp. gr. 1·17, with 1½ pounds of nitric acid of 1·19; putting this mixture into a salt-glazed stone bottle, and adding to it in small bits at a time, grain tin, till 4 pounds be dissolved. This solution (No. 2) may be used within twelve hours after it is made, provided it has become cold and clear. For dyeing three quarters of a pint of the solvent No. 1 is to be poured upon each pound of the pulverised lac-dye, and allowed to digest upon it for six hours. The cloth, before being subjected to the dye-bath, must be scoured in the mill with fuller's earth. To dye 100 pounds of pelisse cloth, a tin or boiler of 300 gallons capacity should be filled nearly brimful with water, and a fire kindled under it. Whenever the temperature rises to 150° Fahr., a handful of bran and half a pint of the solution of tin (No. 2) are to be introduced. The froth which rises as it approaches ebullition, must be skimmed off; and when the liquor boils, 10½ pounds of lac-dye, previously mixed with 7 pints of the solvent No. 1, and 3½ pounds of solution of tin No. 2, must be poured in. An instant afterwards, 10½ pounds of tartar, and 4 pounds of ground sumach, both tied up in a linen bag, are to be suspended in the boiling bath for five minutes. The fire being now withdrawn, 20 gallons of cold water with 10½ pints of solution of tin being poured into the bath, the cloth is to be immersed in it, moved about rapidly during 10 minutes; the fire is then to be rekindled and the cloth rinsed more slowly through the bath, which must be made to boil as quickly as possible, and maintained at that pitch for an hour. The cloth is to be next washed in the river; and lastly, with water only, in the fulling mill. The above proportions of the ingredients produce a brilliant scarlet tint, with a slightly purple cast. If a more orange hue be wanted, white Florence argal may be used instead of tartar, and some more sumach. Lac-dye may be substituted for cochineal in the orange-scarlets.

Dyeing in England.

274. "To determine the tinctorial power of lac-dye by comparison, with proved samples, a dye-bath is prepared as follows:—5 grains of

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Testing tinctorial power.

argal 20 grains of flannel or white cloth, 5 grains of lac-dye, 5 grains of chloride of tin, 1 quart of water. Heat the water to the boiling point in a tin or china vessel; add thereto the argal, and then the piece of cloth or flannel. Weigh off 5 grains of the lac-dye and pulverise it in a wedgewood mortar, with the 5 grains by measure of chloride of tin, and pour the whole into the hot liquor containing the cloth, taking care to rinse the mortar with a little of the hot liquor; keep the whole boiling for about half an hour, stirring the cloth or flannel about with a glass rod; then withdraw the cloth, wash and dry it for comparison."

275. "The Handbook of Dyeing" by **W. Crookes** (page 92) contains the following process for dyeing scarlet with lac-dye:—"For 100 pounds of flannel or yarn boil in water for fifteen minutes 25lbs. of lac-dye, 15 lbs. of muriate of tin, 5 lbs. of tartar, 1 lb. of flavine (the quantity may be varied according to required shade), 1 lb. of tin crystals, 5 lbs. of hydrochloric acid, cool to 170° F., and enter the goods, boiling for one hour, rinse while hot. This is the faster colour than cochineal scarlet."

276. The following extracts from **Mr. McCann's** "Dyes and Tans of Bengal" will convey some useful information regarding the use of lac-dye in this Province as practised by native operators:—

Preparation of dye in Bengal.

277. "The information received as to the processes of dyeing with lac adopted by the native dyers of Bengal is very scanty, and scarcely admits of being presented as a connected account. Lac-dye is used chiefly to dye woollen and silk materials and leather. Where the cakes of lac-dye prepared as above are employed, they are first washed and pounded and then generally boiled in water for about an hour to give the dye a sufficient consistence, *alum* and an *alkali* (generally potash) being added, apparently to heighten the colour (Midnapore). In some districts alum is not employed, the dye being merely boiled with *sajji* or wood ashes (Lohardaga). In Bankura the brightening of the colour is apparently effected by boiling the dye with *lime juice*. In other districts no auxiliary of any kind is employed, the dye being prepared by merely steeping the pounded lac in hot water and then straining through a cloth (Jalpaiguri). Bark of *thanthelang* (**Acacia Intsia?**), which is said to be acid, is sometimes employed in Jalpaiguri to heighten the colour. The liquid obtained as above is sometimes allowed to rest, so that impurities may subside to the bottom; the upper part is then poured off and boiled again (Midnapore).

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Preparation of dye from crude stick-lac.

278. "Frequently the dye when required is prepared directly from the crude stick-lac, and not from the cakes of dye. In Maldah the Collector reports that for this purpose the stick-lac is ground, and then left to soak in water for about six hours (or a whole night) in an earthen vessel, about 12 seers of water being used for about 10 seers of the powdered stick-lac. The quantity of water is given as two maunds in another account. The lac powder is then squeezed and rubbed with the hand and 4 or 5 tolas of *sajji-mati* are thrown in whilst this is going on, and the whole is sometimes well mixed together by rubbing with the feet. It is then strained and the liquid placed in another earthen vessel and boiled; afterwards 15 tolas of the strained powder of the bark of the tree, *lodh* (**Symplocos racemosa,** *Roxb.*) are mixed gradually with it, and it is left to stand for a day. The scum and froth are then skimmed off, and the liquid is strained through a cloth and is ready for use. The liquid dye thus obtained is called *bol.* Sometimes this liquid is further mixed with hot tamarind-water, prepared by mixing 2½ or 3 seers of *tamarind* with 1 maund of water. The proportions given are sufficient to dye 15 yards of silk, which is simply steeped in the liquid, boiled, and then dried. The silk-dyers of Bishnupur, in the Bankura District, employ a similar process for preparing the dye directly from the stick-lac, the only differences being that the ground stick-lac is left to soak in water for a day, and that instead of *saji-mati*, alum or a solution of potash is employed. There is no mention of *lodh* bark, the dye being ready for use after the boiling.

Fermentation induced by flour-paste.

279. "In the Meetapore Jail, Patna, where lac is used for dyeing woollen yarns, the following method of preparing the dye-liquid is adopted:—The cake of lac is washed clean, broken into small pieces, and then rubbed well with a small quantity of water in a large *gumlah.* Water is then added in large quantity to dissolve all the lac, and *flour-paste,* in the proportion of 12 chittacks to 1 seer of the lac-cake, is then added to the liquid and the whole left in the sun for four days, apparently to induce fermentation. It will be found, on reference to Mr. Liotard's Memorandum, that this addition of flour-paste with a view to fermentation is generally adopted throughout the whole of India where woollen materials are to be dyed with lac. No mention of it, however, is made in any of the reports from the Bengal districts except that referred to above. The methods of preparing the dye-infusion above detailed seem to be used

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indifferently, no matter what material—silk, wool, or sometimes cotton—is to be dyed, unless special mention is made of the material.

Cleaning of materials.

280. "The woollen and silk materials seem to be generally submitted to a preliminary cleaning and preparation for the dye before being dipped in it. The Superintendent of the Meetapore Jail, Patna, reports that woollen yarns are prepared for the dye as follows:—'1 seer of the yarn is steeped in *sajji-mati* for about two hours, then washed in clean water and dried in the sun. When perfectly dry, it is again washed in a solution of ½ chittack of *lime* in water, and then dried again in the sun. It is then ready for the dye.' Silk to be dyed with lac is previously boiled for about 10 minutes in an alkaline solution, obtained generally by soaking the *ashes of burnt plantain leaves* in water, and then steeped in a solution of *alum* in water (Midnapore).

"The silk or woollen materials are simply steeped in the dye-infusion prepared as above for a longer or shorter period, or sometimes boiled with it, as in the process adopted in Maldah explained above. In some cases the material is after a time withdrawn from the dye and dried, and then again soaked in freshly prepared dye. In Jalpaiguri endi thread is soaked in the dye for six hours, then withdrawn and dried, and then again soaked for six hours in freshly prepared dye.

Dyeing in Bengal.

281. "In the Meetapore Jail, Patna, the woollen yarn is allowed to remain in the dye-infusion for ten days, being turned every day. After the tenth day the yarn is taken out and washed and boiled for six hours in a solution of 2 chittacks (?) of *lodh-bark* and ½ chittack (?) of *huldi* in 1½ gallons of water. This apparently acts as a mordant, and when the yarn is dried in the sun, it has acquired a permanent red colour. The following account given is of the method adopted by the Meches of the Darjeeling Terai in dyeing silk thread red:—'The thread is first mixed with a plant called *amlia* (**Phyllanthus Emblica**), these are boiled together for some time. The thread is then dried and coloured with lac-dye, and next mixed with the leaves of a plant called *bhauri* (**Symplocos theaefolia,** *D. Don*), and again boiled. When dried, it is of a deep red.'

"Lac-dye seems to be rarely employed in combination with other dyes to produce compound colours. A specimen of silk dyed a brownish purple by *indigo* and *lac* was received from the Rajshahi

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Division, but no details of the process adopted were given. In Jalpaiguri endi thread, dyed with lac as above without the aid of any auxiliary, has its colour heightened by boiling it for one or two hours in a mixture of *monadista* (**Rubia cordifolia**) and bark of (**Baccaurea sapida ?**,) pounded in water." **CHEMISTRY.**

Dye liquor suggested as a manure.

282. *Use as a Manure.*—The dye liquor is a rich source of nitrogen and would constitute a valuable manure for cultivated lands. The liquor, which evolves an intolerable odour in the factory, when evaporated to the consistence of a dry extract, is equal to some of the best oil-cakes in its manurial value. A portion of the nitrogen is present in the form of ammonia, while the balance is combined as an albuminous substance. It should only be necessary to draw attention to this fact to cause agriculturists to apply for the dye as a fertiliser.

Lac-wax.

283. *Lac-wax.*—The peculiar waxy matter of lac is separated from stick-, seed- or shell-lac by employing petroleum ether as a solvent. On a larger scale in the factory it separates on the surface as an oily layer when seed-lac and sodium carbonate are boiled together for some time. Lac-wax is not constant in composition since it varies according to the treatment it has undergone in the manufacture. This wax has a yellowish grey colour, and is said to melt at 59°– 60°. A sample of lac-wax lately supplied to the Indian Museum, by a local factory, had a melting point of 78° C. and the characteristic odour of the raw material.

Composition of wax.

284. Lac wax was the subject of an investigation by Messrs. Benedikt and F. Ulzer in 1888. By treatment with alcoholic potash, the authors were able to separate stearic, palmitic and oleic acids together with myricyl and ceryl alcohols. The wax contained altogether about 50 per cent. of free alcohols of this nature.

This wax is allied to the insect wax of China secreted by **Coccus ceriferus.** Chinese insect wax is used for making candles, for polishing furniture and leather and as a sizing for paper and cotton. On account of its extensive use in China and Japan it is not exported to Europe. The only vegetable wax which bears any resemblance to that secreted by species of **Coccus (Tachardia)**, is the Carnauba wax, a natural exudation of the Corypha palm of tropical South America, but no wax of this description has been found in India.

Properties of Lac-wax.

285. *Properties of lac-wax.*—In the chemical process of purifying lac, alluded to on page 298, Mr. Evans obtained about 1 per cent. of lac-wax as a bye-product. It was harder and more resinous than

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common bees-wax and possessed an agreeable aromatic odour. It combined with paraffin, spermaceti, bees-wax, some of the resins, tallow and animal and vegetable oils. With tallow it made excellent candles, yielding a bright and pure light, but it gave off much smoke when burnt by itself. Its chief use, provided it could be obtained in quantity, would be for making castings, and taking impressions of coins and medallions. It possesses a slight degree of contractibility, it sets rapidly, and its peculiar hardness and freedom from stickiness cause it to quit the mould or object on which it has been applied. Its non-liability to be affected by atmospheric conditions would also render it useful for large seals attached to parchment documents.

Arsenic in lac toys.

286. *Arsenic in Lac-Ware.*—It is well known that yellow sulphide of arsenic (orpiment) is used in the preparation of shel-lac, and as the base of the yellow and green colour of lac toys. Orpiment is an insoluble compound of arsenic, and even in a powdered condition may be handled with impunity. When the toys are well finished by the artisan, and the oil has been thoroughly applied, the colouring matter remains for any length of time in an innocuous form. A danger, however, arises when the water-proofing or varnishing is imperfectly accomplished, and the acids of the lac resin acting on arsenical paint in contact with the air, produces a decomposition of the compound and renders a portion of it soluble in water. Some old specimens of lac toys exhibited in the Indian Museum have shown the presence of arsenic oxide on the application of chemical tests. It is well to draw attention to this fact to show that the commoner kinds of lac toy should not be purchased as playthings for children.

CHAPTER VI.

USES OF LAC.

INDUSTRIAL AND ART USES OF LAC.

287. Lac enters into the agricultural, commercial, artistic, manufacturing, domestic and sacred feelings and enterprises of the people of India to an extent hardly appreciated by the ordinary observer. The existence of the poorer communities in the agricultural and forest tracts is made more tolerable through the income derived from the collection of the crude article. Employment is given to a large number of traders and manufacturers regularly concerned in the production and sale of the various grades of the prepared lac and lac-dye.

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288. *Diversity of Indian uses.*—Every village has its carpenters, cart-wrights and turners, who all use lac in some form or other, either as varnish or colour medium in the production of tables, bed-posts, chairs, boxes, platters, carts and carriages, pails, candle-sticks, powder-boxes, pan-boxes, etc., etc. The silver and coppêr smiths employ lac as a bed upon which to hammer and punch certain of their wares or to effect coloured ornamentations on these in imitation of enamelling and inlaying. The manufacturers of shields, swords and scabbards use lac as a varnish, while the lapidaries make their grind-stones of the same material as they employ to cement blade to haft. The potters, book-binders and makers of smoking-pipes also use lac as a varnish and stiffening material. Painted pottery may be said to have attained a definite position in Sasseram in Bengal, Gonda and Lucknow, in Oudh and Peshawar, in the Panjab, and in these instances lac varnish is used to fix the colours. Occasionally coloured lac is directly applied to pottery and patterns are elaborated upon it by etching (as for example at Kotah) in a manner shortly to be described in connection with turnery. The jewellers load their hollow gold and silver ornaments or fix the stones in jewellery with the same substance. The makers of humbler personal ornaments, prepare the *churis* (bracelets) of the poorer classes of lac and cleverly (through the same material) cause a surface dressing of tin to assume the effect of gold. The dyers and tanners employ lac in the production of some of the more brilliant shades of red and purple given to silken and woollen fabrics or to skins and hides. The producers of agricultural and industrial implements, utilise lac as the chief means of ornamentation, as, for example, with milk-churns, shuttles, spools, bobbins, spinning and weaving appliances, etc., etc. Lac-dye figures as a cosmetic, since it is often used to stain the soles of the feet and the palms of the hands of Hindu ladies. Lastly, in the hands of the toy-maker lac is supreme. All sorts of toys are coloured by it, such as playing-cards, tops, nests of boxes and sets of wooden tea dishes, etc., while marbles, pens, sealing-wax, ink-bottles, imitation flowers and fruits, etc., etc., are entirely made of it.

289. *European Uses.*—In a word the Indian uses of lac are as numerous and diversified as its possibilities of future European development are great. Already it finds a by no means humble position in the commerce of Europe and America. It is extensively used as a varnish and polish for furniture and metal; as a stiffening

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material for hats; as an ingredient in lithographic ink, and as sealing-wax.

Antiquity of the Art.

290. *Antiquity of the Art.*—Lac is perhaps one of the most ancient and most widely known materials employed in wood and metal ornamentation. Certain towns of India have from the most ancient historic times been famous for the rich blending of colours, the depth of tone and the fine polish which their turners (*Kharadis*) have been, and are still, able to impart.

Lac versus Lacquer.

291. *Lac versus Lacquer.*—It seems desirable that a distinction should be here made between lac-turnery and the class of goods commonly known as lacquer (lacker as it formerly and perhaps more correctly was expressed). By modern usage the latter term has come to be applied to varnishes mostly of *vegetable* origin, applied by a brush in *a liquid condition*, the articles being coated at the same time with mud, saw-dust or other substance and repeatedly painted with the varnish and rubbed down again and again until the degree of polish and thickness of coating desired has been attained. Lac ornamentation, on the other hand, is produced from an *insect* resin and is applied in a *solid form*, the heat generated by friction being the agent of its uniform distribution.

292. The art of lacquering has been carried to a high state of perfection in China and Japan. In Burma (Prome), South India (Karnul), Hyderabad (Raichur), Rajputana (Tonk, Bikaner, etc.) and in Kashmir, forms of lacquering are also practised, but these are essentially different in material, manipulation and art feeling from the lac ornamentation. The lacquer of India is in fact much more closely related to that of China and Japan than to the lac-turnery which is the subject of the present paper. Indian lacquer has, therefore, been reserved for a future issue in this publication. But it may be added that of course there are lac varnishes—preparations of lac dissolved in spirits of wine for the most part— that would come to approximate very closely to the lacquers indicated, so that the distinction into lac-turnery and lacquer-ware while convenient and useful is not a logical separation. The present article will indicate briefly the chief varnishes used in India of which lac may be regarded as the chief ingredient.

I.—LAC-WARE OR LAC-TURNERY.

293. With these introductory remarks it may now be convenient to indicate some of the more striking examples, in manipulation and

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style, of lac ornamentation practised in India. I would here explain that for all the finer classes of lac-turnery only the purest forms of shell-lac are employed. The inferior qualities of lac find their place in the other industries for which lac is a necessity. It would also appear that certain results can alone be attained with a particular timber or when a certain combination of colours has been employed. Hence it follows that a study of the timbers and of the pigments is essential to the full appreciation of the art of lac-turnery. I propose, however, to indicate the chief types of that art first and to revert to the question of the timbers and pigments later on. There may be said to be the following styles of lac-turnery :—

Plain Ornamentation.

294. ***Class 1.—Plain Ornamentation.***—An article intended to be ornamented with lac is first turned to the desired shape and polished with a fine powder made from broken pottery. This polishing has the effect of filling up the pores. Should cracks or joints exist, these are plugged up with wood, inferior lac or other materials, and at the same time pieces of cloth are often glued across such imperfections. Articles so treated are subsequently coated repeatedly with a preparation of glue and pottery dust. They are polished after each coating with a sort of chisel made from the leaf-stalk of a palm. All the imperfections and joints are thus made to disappear completely and a smooth and uniform surface is produced. If no cracks or imperfections exist in the wood, the article, after being turned to the desired shape and polished with pottery dust, is directly coated with the colour. For this purpose the *Kharadi* (or turner) takes a stick of coloured lac (a *batti* as it is technically called) and presses this against the prepared article while it revolves on the lathe. The heat generated by friction melts the lac and causes it to adhere to the revolving object. By means of the wooden chisel the lac is still further distributed. The article is lastly polished by a cloth rag, moistened in sesamum or linseed oil. And a peculiarity of this oil-produced polish is that it is not subject to tarnish or to rub off, hence it effectually protects the lac from atmospheric influences.

295. The art of plain lac ornamentation is practised all over India, especially in the preparation of wooden toys, bed-posts, pan-leaf-boxes, etc. The better results attained are for the most part due to several layers of colour and polish having been imparted, the one on the top of the other.

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296. With practically the one exception, *viz.*, indigo, all the other colouring ingredients employed in the manufacture of lac *battis* are minerals, such as orpiment, sulphur, white-lead, red-mercury (vermillion), Prussian-blue, lamp-black, etc., etc. Lac-dye is, however, sometimes used, and in the inferior and modern productions aniline dyes are unfortunately now-a-days extensively employed.

Abri or cloud work.

297. ***Class 2.—Abri or Cloud Work.***—The turnery after being polished or glued and polished in the ordinary way (Class I) has a coating of yellow lac applied all over. The operator then takes in his hand specially prepared *batti* of red or orange colour. This is exceptionally hard, round, sharply pointed and not thicker than a lead pencil. In some cases the pigments used in colouring these hard *battis* would appear to have been dissolved in oil a fact often claimed as a special feature in their production. By allowing the hard *battis* to tremble in the hand and to thus touch the revolving object interruptedly, numerous irregularly shaped spots of various sizes are imparted. By next using a black *batti* of the commoner large flat shape and soft texture, black borders are communicated to the red spots. The remaining interspaces are lastly filled up by means of a white *batti* also of soft texture. But any number of colours may be used, the isolated spots being first imparted by specially prepared hard and sharply pointed round *battis*.

By various modifications of the process thus briefly indicated are produced the pleasing cloud effects that have given origin to the name *Abri* for this class of lac ornamentation. It is practised all over India, but seems to be carried to the greatest perfection in Hoshiarpur in the Panjab, and in Bombay and Sind the art is carried to a high proficiency. In Bengal the spots first imparted are larger, more elongated and less artistic than in Hoshiarpur and the black fimbriation is never practised.

299. From Marara comes another form of Abri-work. A mixture of oil and water placed on the surface of the first coat makes a "watered" cloud-pattern where application of a water *batti* only takes in part. The opaque water colours—ochre or green with a black border—are often made to overlie a transparent polished oil-colour. Modified, this method gives spots, the water being placed in drops to form a pattern.

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Copy of the letter No. 3325, dated the 23rd July 1896, from the Collector of Haidrabad, Sind, Haidrabad.

Sind (Haidrabad). Lac-work of the Haidrabad District.

300. "With reference to correspondence ending with your letter No. 2097—170 of the 10th instant, on the subject of lac-turnery, I have the honour to subjoin the particulars asked for by you.

"I send herewith a packet containing 6 circular boxes, illustrating the various stages of the simplest form of manufacture. The smallest box (marked 1) illustrates the elementary stage and shews a piece of wood roughly hewn into a box by means of the carpenters' adze. The wood is first cut and formed into a block resembling the entire box, the upper part being spherical and the lower circular having a flat base. It is then put on the lathe and smoothed with a file. After which it is cut into two parts, each of which is hollowed out by means of an instrument, called in Sindhi, *Bachi* (a 'turner's point' for hollowing with). Box No. 2 among the specimens represents the stage of manufacture at which it is generally ready for colouring. This is done by applying the yellow colour by pressing a stick of coloured lac against the article while on the lathe, thus making box No. 3. Next comes the process of putting drops of lac on the upper surface of the article as illustrated by box No. 4. Red colour is then applied, see No. 5, and after it is dry, the article is placed on the lathe and smoothed by means of an instrument, called *Khujan* (a kind of file). A little oil is next applied. This gives the colour a sort of brilliancy which is further enhanced by pressing a piece of rag against the article while it is revolving on the lathe. See box No. 6.

Atishi or Fire-work.

301. ***Class 3.—Atishi or Fire Work.***—The peculiarity of this style may be said to be that, after the article has been carefully prepared and polished with pottery-dust, it receives a coating of finely divided tin made into a paste with glue, the coating being either uniform or made up of a multitude of minute dots after the fashion of the *Abri* work (*Class II*). Over the top of the tin, red or yellow lac is next applied, with the result that the object obtains a rich fiery or golden glow. It is then polished on the lathe by means of a shell, known as the *mohra*; this communicates so much heat that the lac becomes more transparent than is the case in the other methods of lac ornamentation.

302. *Atishi* is largely practised in Hoshiarpur, Jampur and Dera Ghazi Khan, in the Panjab. Without exactly manifesting the fiery glow, the lac toys and boxes of Indergarh, in Rajputana, and of Podanur in Madras, exhibit a depth of colour and purity of polish that approaches closely to the *Atishi* style.

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At Marara, *Abri* work of the type described over a sheet of tin-foil laid on the wood produces a very pleasing effect, the ground colour made transparent, allows of the reflection of light from the tin below and the clouds lie opaque on it.

Nakshi work

303. ***Class 4.*** - ***Nakshi (or Pattern) Work.***—Of this style there are two well-marked sections.

(*Section A.*)—*Oiled and Scraped Nakshi.*—An example of *Atishi*-ware (*Class III*) polished with *pipa* (brick-powder) and with mustard oil, has patterns, floral designs, or hunting scenes, etc., etc, subsequently worked on the surface. This is accomplished by scraping off lines loops, or patches of the polished and oil-varnished surface and then applying a soft flat *batti* as the article revolves on the lathe. The portions scraped off receive the new colour, but none of the intervening oil-varnished spaces do so. The object is again polished and oil varnished all over and further portions scraped off when these in turn are given the next colour that may be desired. This is repeated time after time until the floral and other designs or pictures have every outline and detail of colouring imparted to them.

This art attains its highest perfection in Hoshiarpur in the Panjab, but is less skilfully practised in other districts. Such as at Bagri and Sojat of Marwar in Rajputana.

304. Rao Bahadur P. Sukdev Prashad, Judicial Secretary to the Masaheb Ala of Marwar, describes a beautiful modification of scraped Nakshi. He lays special stress on the fact that certain coloured *battis* (or lac sticks) have been prepared with oil, others with water. A bed-post coated with a red oil-prepared *batti* has numerous straight parallel lines $\frac{1}{8}$th inch apart scraped off certain portions. By means of a yellow water *batti* then become lines of yellow or other colours on the red back ground. The bed-post is next made to revolve rapidly on the lathe and a rag of cloth moistened in oil is firmly pressed against the lined portion. The heat generated melts the coatings of lac and drags the lines into beautiful wavey courses.

305. A special reference was made to Haidrabad, Sind, in order to procure information regarding the lac-turnery for which it used to be famous, *viz.*, that with painted hunting scenes. That particular branch of the industry may be found described on page 316.

The following passages from letters received would appear

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to allude to scraped Nakshi and are accordingly given in this place :—

Extract from letter No. 946, dated the 2nd March 1897, from the Collector of Haidrabad, Sind.

306. "In reply to your letter No. 2400—170, dated 6th August 1896, I have the honour to forward copy of a letter to my address from the Assistant Collector, Hala,* in which that officer gives a further account of the industry in lac and lac toys, and trust that it will prove to be what you require.

"The colouring of animals and flowers is also not very accurately described by the Assistant Collector. The workman digs out the pattern or figure which he wishes to make upon the wood after the surrounding back ground has been coloured. He then applies to the whole block the colour which he wishes to give to the flower, for instance, having laid on this colour sufficiently thickly, he scrapes it off again until the original colouring of the back ground once more appears. The colour which has been given to the flower and which has sunk in below the surface of the back ground remains. The process of sinking in colour and then smoothing it down can be repeated indefinitely."

Process of describing figures and circles on the work.

Figures and circles work.

307. "After the wood has been brought to the stage, when *Khurchan* is used the process of scraping with it is dispensed with and it is smoothed with the palm bark, then with an instrument called *Rachi* (an iron bar about 10 inches long, $\frac{3}{4}$ inch thick and pointed at both ends) and a compass, figures, and circles are described with the hand on the toys, etc., which are then again placed on the lathe, smoothed with the bark and *Khurchan* oiled and cleansed with a rag finally coloured and the colours sticking into the cavities created in the process of scraping the figures."

Etched Nakshi.

308. (*Section B.*)—*Etched Nakshi.*—In this class of turnery the object is coated with first one colour, then on the top a second, a third or a fourth, uniformly all over. The *battis* employed are for the most part the common soft flat kind. The first colour is usually yellow, the next red, followed by green and last of all by black; but of course any assortment or number of colours may be imparted layer upon layer, the one on the top of the other.

With a fine chisel or style the lac-coated surface is now scratched, the hand being made to move lightly or to press heavily as may be necessary to bring out the colour required from the numerous layers beneath the surface. In this way, upon a black back-ground, yellow

* Passage from the Assistant Collector of Hala's Report alluded to above.

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stems and leaf-stalks, green leaves and red flowers with yellow or parti-coloured veins and shadings may be elaborated.

309. In Pak-Pattan and Montgomery the floral designs usually produced, manifest a softening and blending of the colours that bespeak great skill and delicacy of touch. In Ferozpur the fern-like ornamentation assumes a geometric arrangement of spaces. In Dera Ismail Khan ivory bottons or discs are given as centres for an elaborate and minute floral pattern. In Sahiwal of Shahpur in the Panjab a bold open style of this art is practised in which two colours only are as a rule employed. The surface colour is usually a dull black and the etched pattern is in the second colour, *viz.*, red, yellow or green. The design has a strong Greek feeling and is perhaps the more artistic because less elaborate than the style of Pak-Pattan, Montgomery, Ferozpur and Dera Ismail Khan. In Jaipur hunting scenes are cleverly etched in which the shading and colouring of the figures is attained through the varying degree of pressure given to the chisel.

310. In Agra two colours only are as a rule used, red and white, black and white, etc., the lighter colour being underneath, so that the pattern shows up somewhat severely. The pattern is mainly floral the colouring or shading of the petals being brought about by parallel lines. In Indergarh and Gainta towns of the Kohat State in Rajputana, two very distinct schools of this class of lac-turnery exist. The Indergarh style may be said to be characterised by great depth and purity of colour with a boldness and sharpness of design that is very charming. As a rule four colours are employed, the petals of the stellate flowers etched out being parti-coloured. Gainta, on the other hand, is strongly aboriginal. Alternate bands have either a green or a yellow pinnately floral design with spirally formed flowers elaborated on a dull black back-ground. Brighter colours seem never to be resorted to and the patterns closely approximate to the cross-stitch embroidery of the wild hill tribes of Rajputana. Some work from Marwara has a similarity of pattern.

311. Throughout India the art of lac-etching is known and practised, the designs varying with the art instincts and religious feelings of the people. Usually it is only resorted to for the illumination of small portions, such as the borders, of otherwise plain lac-ornamentation.

312. The following passages from the writings of authors or the com munications of an extensive series of generous correspondent

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may be given in anticipation of the foregoing observations regarding this art:—

Extracts from letter No. 3630, dated the 6th June 1896, from the Collector of Agra.

Agra.

313. "In reply to your No. 369—170, dated the 21st February 1896, I have the honour to submit a report on the subject of woods and materials used in the lac-work industry in the Agra District.

"The only Tahsils or Sub-Divisions in which this industry is carried on are Ferozabad, Falehbad and Agra; but in all places except Agra city itself, the industry is confined to manufacturing and colouring small toys for children. In Agra city considerable progress has been made since 1878, so that in addition to toys the artisans here prepare small boxes of different descriptions, cups, saucers, baskets, small tables, frameworks and stands for looking-glasses, chess-boards and other similar articles. These articles are not only sold locally, but are in some quantity exported."

Etched lac-turnery.

314. *Etched lac-turnery.*—A first coating of yellow lac is invariably given, and over this is placed a second coating of the required colour, or super-coated. The article is then varnished. Any ornamentation that is needed is done afterwards by hand, with steel-pen, which scratches out the outer colouring or coating, leaving the yellow ground-work exposed. The portions thus exposed are then coated over with a solution of old lime or chalk, and after the solution has dried up the article is rubbed over with a duster and is ready for the market.

"The articles sent to you have all been supplied by Mian Jan, son of Ghis Mohammad of Kharade tola, Agra, who requires no payment for them. He only stipulates that if any of the articles be considered fit to be kept in the Museum he should be named on the label as the donor."

Extracts from note on the Indergarh Lac-work industry in the Kotah State by Babu Durga Pershad, Hakim *Kotriat, Kotah.*

Kotah.

315. "Indergarh, the capital of a Chiefship of that name in the Kotah State in Rajputana, is noted for its lac-work industry. Wooden articles are coated with one or more layers of lac of different colours on which various designs are traced. Circular boxes, balls, toys and sundry nick-nacks are made in this way; particularly lacquered wooden cups, goblets which are used for toilet purposes.

"Blocks are prepared first with a *Basoola* (Indian adze) and then turned into the required shape on a native lathe. An imperfect contrivance which gives so many turns in one direction and so many in the other according as the string which encircles it is pulled by the assistant. The instruments used for shaping the exterior and interior of the cups are called '*Nohlia*' (a sort of gouge) and '*Kholna*' (brad awl), a common chisel, is used for smoothing the surface.

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"When the cup is ready to be coloured, it is first coated with one or more, but never more than four, layers of lac of different colours, and then the designs are traced with a sharp edged chisel, the required colours for flowers or leaves in a floral pattern being obtained by cutting the layers to the required depth.

"The coatings of colour are laid on the wood whilst on the lathe in the following manner:—

"While the cup is rapidly revolving, a stick of coloured shell-lac is pressed to it and the friction develops sufficient heat to make it adhere to the wood, and then a piece of *Khajoor-ki-dandi* (the leaf of the date palm), or *Khajoor-ki-ghar* (stem of the date fruit), and *Keora-ka-patta* (leaf of the screwpine) are pressed successively against the revolving surface to make the colours smooth and glossy.

316. From Indergarh an interesting series of etched lac-ware has been received, amongst which may be mentioned the *Singardans* or groups of dome-shaped toilet boxes; the *phul kanual* or lotus flower that unfolds its petals on the screw being turned; and imitation flowers and fruits. From Gainta have come sets of Singardans on stands and a curiosity in the form of *Basudeojee-ka-dibba* (a box containing an image of "Basudeo," the father of "Krishna," when water is poured in the box it will remain in the box so long as it does not touch the feet of "Basudeo" but as soon as the water does so, the box will become empty—the water running out).

Lastly, *Painch-ka-dibba* or box that cannot be opened or shut until certain marks are brought into a required position.

Painted Ornamentation.

317. ***Class 5.—Painted Ornamentation.***—In this class of the work articles to be ornamented are repeatedly and carefully coated with glue and fine pottery-powder. Thereafter they are elaborately smoothed and polished. When a sufficiently good surface has been obtained, certain portions (panels or medallions) upon which bunches of flowers, groups of animals, hunting scenes or mythological pictures are to be given, receive a coating of white paint or chalk. The desired illuminations are then made in water colours, and, when quite dry, are varnished. The articles are thereafter again placed on the lathe and the designs completed by one or all of the methods of lac ornamentation.

318. This art attains its highest perfection in Haidrabad, Sind, and in Jaipur and Alwar. In Benares and elsewhere crudely painted designs are sometimes given to otherwise plain lac-ornamentation.

Extract from a note on the Jaipur Lac-work by Colonel T. H. Hendley, C.I.E., *furnished with the Resident's letter No. 3484, dated 12th December 1896.*

319. *Painted Animals.*—"These figures are painted in the usual wall painting process. The ground is first prepared with a coating

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of powdered *Thickri* (Kilned earthenware) and boiled glue—a cloth rag is used to cement the joints to prevent cracking by shrinkage from the atmosphere—as many layers of cloth are applied as are necessary, and of this the painter is the judge. Then coating with white lead is applied, and Turpentine and *Chandra Rojan* (varnish) which is called *Bat* (*Safeda-ki-Bat*). This *Bat* is applied over and over again until the required surface gets perfectly smooth and then an animal, or a hunting scene, or any figure to the fancy of the painter is drawn upon it in water colour and varnished with the *Chandra Rojan* as said above, which process is called Abdara by the painters.

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Painted animals.

Abdara.

320. ***Class 6.—Coloured Metal Ware such as Produced at Moradabad.***—Lac is very largely used in the metal industries, both to impart colours in imitation of enamelling and inlaying and as a varnish to improve or preserve the colour of the metal. This art may be briefly described as follows. The vessel is cast in a mould in the ordinary way. It is then filed down roughly and later is placed on a turning lathe (*chhalai*) where it is ground into final shape and polished by means of an iron chisel which is sharpened on the stone known as *Korant-ka-pathar* or corundum. The vessel is now placed on a bright coal fire and made red hot. It is then sprinkled with powdered *Nausadar* (sal-ammoniac) and rubbed with *Ranga* (pure tin), the *Ranga* being diffused by means of a cloth dipped from time to time in the powdered sal-ammoniac. The vessel thus tinned is allowed to cool. It is next deeply engraved. Once more it is placed on the fire. This has the effect of temporarily dulling the tinning but of making it more durable. While still hot, sticks of coloured lac (*battis*) are rubbed over the portions of the surface that are intended to receive colour. The vessel is then allowed to cool and is once more placed on the turning lathe. Ashes mixed with powdered pottery or brick-dust are sprinkled over the surface and well rubbed in by being held firmly between dry leaves of the date-palm. A mixture of powdered emery (*korant-ka-pathar*) and linseed is similarly pressed hard on the vessel as it revolves on the lathe. The result is that all the coloured lac that had adhered to the higher portions is removed, while that within the engraved portions remains and at the same time the surface is beautifully polished.

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321. A somewhat remarkable feature of the ornamentation of metal objects with lac is that the green and purple pigments employed are aniline dyes. The red is, as a rule, red oxide of mercury and the black lamp-black, but the gaudy colours that have recently been

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introduced and which have degraded and demoralised the art, are all aniline. Formerly Moradabad-ware had a distinct position of its own. The back-ground was uniformly black and a rich floral design, partly in silver and partly in gold colour, was traced in imitation of the inlaid *Koftghari* of Sialkot, the Niello of Burma or the Bidri of Hyderabad. In fact, so elaborate and beautiful was the sunk lac that the elevated metal design was by most persons taken as inlaid wire. All this has practically vanished. The patterns now worked are large blotches of green, purple, black and red and are as vulgar and inartistic as it is possible to conceive. Moradabad-ware has no longer a style and recognised position of its own, but, like the Jaipur pottery in Bikaner lacquer, it appeals to the vulgar craving for novelty at the expense of artistic conception and suitability. But it is perhaps worthy of note that the monstrosities that have of late appeared have for the most part not been produced at the ancestral home of the industry.

322. A recent Moradabad development, not devoid of merit, may in conclusion be mentioned, *viz.*, that in which the design appears to be worked in black the back-ground being a polished brass surface. This while not inoffensive, is doubtless less troublesome and expensive than the older style where the engraving was carried to such an extent that all that remained of the original metallic surface was a delicate floral design in what appeared silver and gold wire.

OPINIONS OF AUTHORS.

SOME ACCOUNTS OF LAC IN INDIAN ARTS.

323. In amplification of the foregoing observations regarding the various classes of lac-turnery that exist in India the following extracts from published works and correspondence may be here given. It will be observed that the passages to follow deal with all the classes already described, but in such a manner that they could not be cut up and distributed under sections without being seriously injured.

Passages taken from the Hand-book of the Manufactures and Arts of the Punjab, by **B. H. Baden-Powell, Esq., I.C.S. C.I.E.,** ***pages 211-213.***

Turned and Lacquered Ware.

324. *Turned and Lacquered Ware.*—There are two prominent kinds of work which deserve separate mention; one is the *Kár-i-kharát* or turned and lacquered ware, known to the Europeans by the name of Pakpatan work; the other, the turned work of Dera Ismail Khan.

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325. The kharat work consists of turned wood boxes, cups and toys, the outer face of which is prettily coloured with a coating of mottled lacquer.

326. The best work in the Panjab is done in the Montgomery District (late Gugaira) at a place called Pakpatan; but the art is by no means confined to this place. I have specimens from Delhi, Amritsar, Lahore (both the city and the sub-divisions of Sharakpur and Kasur), Shahpur, and the Derajat. Of the Derajat work I shall give a separate notice.

327. The lacquered work has a fine polish and generally a marbled or mottled appearance, often in two or three colours, and the article finished with a flowered border which latter is done by a species of handiwork different from the rest, and certainly affording a good instance of the delicacy of native handling.

The process of making the lacquered ware may now be described:—

328. The turner's apparatus is very simple; he has first a strong wooden frame made fast to the ground and furnished with two uprights, between which the block of wood on which he is to operate revolves. One upright is fixed, and furnished on the inner side with an iron spike which forms one point of suspension; the other upright is capable of adjustment at a quarter or less distance, according to the size of the work—it slides along the under bar of the frame, and is fixed by a peg in one of a series of holes in the bar. When adjusted to the required distance, a piece of hard wood, generally shisham or box, is supported by the iron spike in the fixed upright, and a rather long iron pin run through a hole in the second, and thus the block is freely suspended on points between the two uprights. The iron pin is prolonged beyond the support, and is turned by a bow. The bow is fitted with a leather cord, which being once twisted round the projecting end of the pin, is worked backwards and forwards saw-like, thus communicating a rotatory motion. The turner sits on the ground, gains a fine purchase by putting his foot against the framework, and moulds the article with chisels. The machine is kept going by a small apprentice, who saws away with the bow, and is supposed to learn the art meanwhile.

So soon as the article has attained the required shape, it is ready to be lacquered.

The colouring matter consists of thick short sticks (*batti*), of a composition of lac, resin, colouring matter, and, it is said, with a certain admixture of sulphur and bees' wax.

329. Mineral colours are mostly used. The yellow is made with orpiment; green with arsenite of copper; red with red lead or vermilion; blue with imitation "lájward" or Prussian blue ("wilaiti nil"). But a pretty transparent crimson is produced with the red of the lac-insect; and black with lamp-black. When about to apply the sticks of lacquer colour, the wooden article duly smoothed and clean, is set on the turner's frame and made to rotate. If the colour to be produced is an uniform surface of lac colour, the lac-stick is pressed rather hard against the wood and the colour

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comes off, as the heat produced by the friction is sufficient to soften the lac and detach a portion. When enough colour has been applied, the article looks dull and streaky, but a piece of bamboo is taken and a fine edge put on it with a chisel; this is skilfully rubbed over the surface of the article till the colour has evenly spread, and by skilful manipulation a polish begins to show on the surface, which is enhanced by a gentler application of bamboo edges, and finally completed with oil and rag. To produce the mottled appearance so much admired, the sticks of colour are selected of a rather harder composition, and less easily softened by heat. The article to be coloured is set revolving, and the workman, holding the colour stick against it very lightly, allows a point here and a point there of colour to attach itself; the wood soon appears to be sprinkled over with coloured dust.

The workman takes another colour, and repeats the process moving the stick up and down along the revolving block, when by his skilful manipulation the second colour adheres at points which the first colour has left blank; sometimes a third colour is touched in in the same manner. When enough colour is on the surface, the different points of colours are rubbed together and combined into a mottled or marbled appearance by rubbing, as before described, with a bamboo edge, and finishing with a rag and oil. The prettiest mottle is that of crimson and black, crimson and white, and blue and black. Around the rim of a box or lip of a cup, a border is often put on, with a flower pattern on it, which is done in a different way.

The article is again set spinning on the frame, and colour applied where the desired border is to come, in a uniform band, and well rubbed in and smoothed with the bamboo; a coating of red is always given first; over the red, a coating of green is applied till the red disappears, and over the green, black.

The flower pattern is produced by hand with a small sharp chisel; so delicately does the workman adjust the force and depth of his cut that he will, for the flower, let us say make it appear red by cutting away the black and green coats and exposing the red layer, for the leaves he will scratch down to the green one and for a white line he will cut down to the wood. A mistake seems never to be made in this work: a slip of the tool would of course spoil the whole.

330. The turned work from the Derаját (Dera Ismail Khan) differs from that of Pakpatan. The variety of articles made is much less: the favourite article is a round box with a domed lid. The mottled surface is not given; but three coats of colour, red, green and black, are applied as just described, and the pattern entirely produced by the chisel. The lines produced are often silvered with an amalgam of mercury and tin-foil and the appearance is very pleasing. The boxes are further ornamented by carved ivory knobs, etc.

331. It will not be interesting to give a list of specimens. At Pakpatan all kinds of cigar boxes, vases and trays, croquet mallets and balls, children's toys, etc., are made, and a list of them would be useless.

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I conclude the class with a descriptive list of the turner's tools :—

(1) "Nán."—A large, heavy, narrow-bladed chisel, for the first operation of rough clearing the wood.
(2) "Nihán."—A broad chisel, rather heavy, with long wooden handle, for neat cutting ; also called Máthná.
(3) They rest their tools on an iron bar "addi" placed close below the revolving block of wood, and press the edge of the tool against the wood, moving it from side to side.
(4) "Buráki."—A pointed chisel to cut out screw, grooves, etc.
(5) "Chírná."—A heavy iron bar, terminating in a flat blade at either end, only the point of which is sharpened edgewise. Grooves can be cut, and a cylinder separated into pieces by this.
(6) "Rachí," and "Roda."—A bar worked into a blade at either end.
(7) "Sathra" "Sathrí."— Narrow edged chisels of sizes.
(8) "Bánkiya" for cleaning out the inside of vessels intended to be turned hollow. It is like a hooked bar, the edge of the hook being flat and sharp.
(9) "Tesha."—Adze.
(10) "Rangáta."—The polishing stick.
(11) "Varma" of sizes.—This is the universal tool for boring holes.

He has also saws and files, which need no description.

Passages taken from the Indian Art Journal, Vol. III., April 1890, page 36.

Lacquer-work and Turnery.

332. *Lacquer-work and Turnery.—The Kharadi* (turner) is found in every town and large village. His work is to be seen in every villager's house. Much of his work is crude in design and colour, and rough in execution, but it improves *pari passu* with the increase in refinement and wealth of the purchasing public: thus the manufactures of the city-turners are in general better in quality than those of his village brother.

333. The turner's instruments are rough and primitive, and are mainly country-made. In common with the rest of the *tarkhan* class, however, he is slowly finding out the merits of English steel, and one frequently finds that his chisels, saws and files are of English manufacture :—(1) The lathe (*adda*) consists of two iron bars (*killa*), one fixed in the ground, the other to be adjusted for distance. On the inner side of each bar is a spike, to which the block of wood to be turned (*mochha*) is attached. Between this block and the adjusting bar over the spike is fixed a cylindrical peg (*chari*), round which the thong of the bow (*kaman*) is once passed. The bow is worked backwards and forwards, and thus imparts the necessary rotatory motion. (2) *Nan, nihan,* heavy chisels for the operation of rough cleaning the wood. (3) *Mathna*, a light chisel. (4) *Addi*, the rest for the chisel. (5) *Buraki*, a pointed chisel for grooving. (6)

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Sathra and *sathri*, narrow-edged chisels of sizes. (7) *Churna, rachi, roda*, an iron bar, ends flat-bladed, the edges sharp for separating the cylinders, etc. (8) *Bomkinja* or *patra* for cleaning out the insides of vessel to be turned hollow. (9) *Tesha*, the adze. (10) *Varma*, the drill. (11) (*Ari*) saws and (*reti*) files. (12) *Rangata*, the polishing stick, etc. The woods used are shisham and poplar.

334. After the articles have been turned to the required shape on the lathe, the colour is applied by pressing sticks (*batti*) of coloured lac to the revolving surface. Sometimes two or three colours are laid on in patches to produce a mottled or marbled ground (Dera Ismail Khan). Borders are usually made in two or three colours superposed and the pattern is etched with a chisel. When colours are superposed, the invariable order is first red, second green, and third black. The coating of colour is rendered even by means of the polishing stick, a piece of bamboo, or the midrib of a palm-leaf. To produce a pattern in green the black is scraped through, for red both the green and black are scraped away, and for white the wood itself is exposed. The lac stands well the extreme heat of the sun and the damp of the rains, but cannot be compared in these qualities to Japanese lacquer-work.

335. The colours are mostly mineral. Yellow is made with orpiment, green is the arsenite of copper, red with red-lead or vermillion, blue with *lajward* or Prussian blue, black with lamp-black. The usual method of manufacture is as follows :—Yellow.—Quarter seer shell-lac and 2 chittacks sulphide of arsenic (*hartal*); pound the latter in a mortar, mix the shell-lac in, and warming gently, mount the mixture on a stick, cool, and take off the pigment and roll it into a cylinder (*batti*). Red.—Quarter seer shell-lac and 2½ chittacks of vermilion; treat with water and pound for several hours, dry and mix with shell-lac and proceed as for yellow. Green.—One chittack yellow; warm and mix one tola of indigo and proceed as before. Black.—Quarter seer shell-lac and 2 chittacks lamp-black, etc. Blue.—Quarter seer shell-lac and 2 chittacks carbonate of lead; pound and mix indigo, etc. *Lajward*.—Quarter seer shell-lac, 2 chittacks white lead, and 4 tolas bottle colour (*ajaib rang*), warm shell-lac gently, mix the two other ingredients slowly, etc.

Centres.

336. The following places may be regarded as centres of the trade :—Sahiwal (Shahpur District), Dera Ismail Khan, Pakpatan (Montgomery), Ferozpur, Hoshiarpur and Jullundar. Sahiwal lacquer work, as compared with that of other centres, is rough and crude. It is, however, characterised by great freedom in design. Aniline dyes are much used, an aniline mauve being peculiarly unpleasant. The work done in two colours is most effective. The Dera Ismail Khan work is unique in character, very few colours are employed, and the pattern is usually of fern-like scrolls of almost incredible minuteness and delicacy of execution, mostly wrought or scratched by women. The caskets, tables, etc., are lavishly ornamented with ivory studs, flowers and similar ornaments. Pakpatan articles are remarkable for solidity of surface and design. At Ferozpur, the work of an old pupil of the Mayo School of Art is skilful in execution and artistic in design. He uses the *farash* (**Tamarix orientalis**)

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and not, as elsewhere, the shisham and poplar. His work is the best of the kind in the Province, but it is very high in price. The Hoshiarpur lacquer-work differs from that of Pakpatan in the use of metallic tin ground under transparent colour, and in addition to the scratched work of colour, figures of a mythological character are boldly painted and covered with transparent lacquer. The brilliance in colour is secured by the use of aniline dyes, which are used to effect the same object at Dera Ismail Khan and at Sahiwal. "Another peculiarity is the scratching of lines of ornament or figures in one colour of lac, and then filling the lines with another colour, the whole surface being made smooth. This is the method followed in Burma, only the lac is applied on basket-work, and not on wood. Rude figures of divinities are freely introduced, and larger pieces are attempted here than elsewhere. Little care is, however, taken in the selection of the wood."

Copy of letter, dated the 15th June 1896, from Dewan Tek Chand, Esq., ***Assistant Commissioner, Hoshiarpur, to the Deputy Commissioner, Hoshiarpur.***

337. With reference to the enquiries made in the letter of **Dr. George Watt**, Reporter on Economic Products to the Government of India, dated Calcutta, the 21st February 1896, I have collected the following materials relating to the lac-work industry in the Hoshiarpur District. For facility of reference I have arranged my materials under headings I, II, III, IV, V, each heading referring to a specific enquiry contained in **Dr. Watt's** letter.

338. "I. *Timbers used in Lac Toys.*—The wood that is most used here in making toys and circular boxes, etc., which are afterwards coloured with lac is '*tahli*' or *shisham* **(Dalbergia Sissoo)**. The black *tahli* is, however, not much used, as the lac colour on it does not come out bright and well. Excepting the legs of bed-steads for which black '*tahli*' is more frequently used, all other lac-work is chiefly done on white '*tahli*.'

339. "*Timbers used for Bobbins, etc.*—I do not exactly understand what is meant by a bobbin.* The nearest approximation I can get here is either a shuttle or a spool for winding cotton yarn upon. As regards spools, almost any wood may be used. **Timbers.**

340. "*Shuttles.*—In order to make a good shuttle the wood ought to be hard, tough and above all *smooth*, the slightest split at bottom being apt to tear the threads when the shuttle runs to and fro through the loom. I send two specimens (7929-1) made of *khair*, and (2) made of *kahu*. It may be noticed that they are not coloured at all, at least the coloured shuttles are not used in this district. **Shuttles.**

"II. I send two specimens of '*tahli*' marked 3 and 4: 3 is a piece of white and 4 of black '*tahli*.' 3 and 4 are really parts of the

* Frequent reference having been made to the Reporter on Economic Products by the owners of cotton, jute and woollen mills for information as to Indian woods that might be suitable for the manufacture of bobbins, opportunity was taken, while investigating the lac industry, to enquire into the subject of the woods employed by the Indian turners in the preparation of lac toys, boxes, etc., from the belief that these might also be used for bobbins.—*G. Watt.*

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same wood, 3 being the exterior and 4 the interior portion. In order to illustrate it I send a round piece 5 which shows both conditions.

Spools.

341. "III. *Spools.*—I furnish three samples in illustration of the manufacture of a coloured spool which is so frequently used here for winding cotton yarn on, and making it into cross skeins. They are marked 6, 7 and 8.

"6 is the crude form of a spool. The two heads are made of *diyar* (*deodar*) wood, and the stem or rod connecting them is made of bamboo. Bamboo wood is often used in this subsidiary way to finish up a toy as it is not easily breakable.

"7. This represents the first stage of a lacquered spool. A stick of coloured lac is heated and then pressed all over to give it a varnish.

"8. Over 7 a golden lac-leaf is first carefully pasted. Then on it again small clipped pieces of red, green, and white lac-leaves are affixed to give the spool a gaudy appearance.

Lac leaf.

342. "*Lac leaf.*—Samples of red and green lac-leaves are also sent under cover 9. The method of making these leaves is very simple. A quantity of lac-seed is put in a small bag which is knotted on the top and then placed in a small oven called '*tokhani.*' When it gets hot it is taken out. Meanwhile a tin-foil is placed on a frying pan which also gets warmed up on the burning coals. On this tin-foil the lac bag is slowly moved from one corner to another, the lac-dye oozes out all the time and the whole tin-foil becomes coloured with lac.

Churis or Bangles.

143 (*i*) *Churis or bracelets.*—"I send four specimens marked 10, 11, 12 and 13.:—

"10. This is a plain bracelet made of kach or glass.

"11. Here a plain bracelet is gilded over with lac-leaf.

"12. A bracelet of the form (10) is made warm and dyed with a lac-stick, and then on the outer surface of it lac-leaves are pasted as in the case of spool 8.

"13. This bracelet is entirely made of lac, the top of it being covered over with a piece of tin-foil. The inside of this particular bracelet consists of good lac, but ordinarily only phog (*i.e.*, refuse of lac after shell-lac has been made from it) is used for the purpose.

"A specimen of *phog* is sent under cover 14.

344. "IV. *Preparation of Lac—Seed-lac*—Lac as collected from the trees is shewn under cover 15 (if it is wet, it assumes when packed in gunnies the form 16). The larger pieces of this lac are collected together, dusted and washed in plain water. They are then powdered, and the stuff is mixed with some water which after boiling in a caldron in which some *sakki* and *sajji* are also put, is allowed to get cool. The whole thing is afterwards put in a vessel to the mouth of which a piece of cloth is tied which thoroughly closes it. The vessel remains stationary for a little while, after which the coloured water is made to filter through this piece of cloth, when all the water runs out some residue is left at the bottom of the vessel, which is called *lakhi.* It is from this that the lac-dye, in the proper

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sense of the term, is made. Its specimen is shown under cover 16*a*, *sakki* under 17, and *sajji* under 17*a*. It may be remarked here that with 5 seers of lac the mixture used is as follows:— **ARTWARE MANUFACTURES OF LAC IN THE PUNJAB.**

1. Water	. . . . . .	5 seers.
2. Sajji	. . . . . .	$\frac{1}{4}$th of a seer.
3. Sakki	. . . . . .	$\frac{1}{8}$th of a seer.

"If lac 15 is dusted and mixed, not with plain water as before, but with water which is *Misalah-dar*, *i.e.*, water boiled with *Sajji* and *Suhaga* (Borax), then the residuum is called lac-seed, for which see specimen (18)."

345. *Chapra or Shell-lac.*—"Before stating the process for making coloured lac-sticks it seems necessary to say a few words about the formation of what is technically called *Chapra*, but colloquially known as *papri*, perhaps from the turn-out resembling a *Papar*, a thin crisp cake made of pulse. The lac-seeds after they are well washed are stuffed into a cloth bag, the mouth of which is tied with a piece of string. This bag is then heated over a fire, the lac inside naturally melts and through the pores of the bag emits a kind of resinous frothy substance which is at once removed by the artisan with a scraper. This frothy substance is then laid flat on a stone and at once turns into thin plates. The refuse left in the bag is called *phog* which is already referred to, is used in making bracelets, and also sometimes by goldsmiths in filling up hollow ornaments and by turners to patch up fissures in wood used for turnery. **Chapra or Shell-lac.**

346. *Qualities of Lac*—"I send two samples of *chapra* under covers 19 and 20. 19 is made from *hari* lac, *i.e.*, lac collected in the month of *Har* (June-July). 20 is extracted from *katak* lac collected in October-November. The latter is darker in hue owing to, it is said, the mixture of rain-water with lac-germs in the rainy season. **Influence of rain on lac.**

347. "Sometimes before making the shell-lac the artisans mix some *biroja* (21), rosin of **Pinus longifolia**, with the lac-seed. The reason for this mixture they give is, that the shell-lac gets more suitable for *light* colouring. The price of this what may be called 'impure' shell-lac is lower than that of the pure article, and it is not unlikely that the *biroja* is mixed to increase the weight without damaging its properties to any very appreciable extent. Specimen of this 'impure' shell-lac is given under cover (22).

348. *Lac-sticks or Battis.*—"They are made from *chapra* and not from *lakhi*. *Lakhi* (dye 16 *a*) is not used in making these sticks excepting No. 37, in the formation of which both *chapra* and *lakhi* are used.

349. "The process of making a coloured lac-stick may now be briefly described. Three or four *chapras* are joined together and brought near live coals placed in an oven, where they soon begin to soften. The artisan pulls the softened material like a wire with his right hand, the left hand holding a stick on which the wire is wound and unwound during the process. It is then well beaten and made into a ball (specimen 23). When its colour becomes deep yellow, the piece is then removed from near the *tokhani* (oven) and placed on a small wooden-stand made fast to the ground in order to receive a good **Manufacture of Battis.**

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hammering. The ball is then made flat, the sides are raised so as to leave a depression in the centre in which a variety of colour-substances are placed according to what colour the lac-stick is intended to bear. The whole is afterwards thoroughly beaten up by a hammer until the colour-substance gets well mixed up with the *chapra*. The artisan stretches this mixture, makes it into a kind of round pencil with the palm of his hand and then flattens it into the ordinary shape of a lac-stick with his fingers.

"I send specimens of 14 coloured lac-sticks, but they are to be considered by no means exhaustive. The process is the same in the formation of each of the sticks—the material mixed with the shell-lac being ordinary colour (*i.e.*, colour substance) bought from the bazar. Some remarks, however, may be made as regards a few of the specimens.

350. 24. *Yellow.*—"The substance mixed here is *hartal* (orpiment). As the colour of the *chapra* wire, above referred to, is already yellow, that colour is easily developed.

351. 25, 26 and 27. *Green.*—" It is rather curious that in making a green stick the artizan first puts the same *hartal* which is used in 24 only in less quantity. Afterwards he mixes the powdered green colour sold in the bazar. I asked him the reason of his putting in *hartal* and he said that with any other mixture the green colour does not come out well. So that in stick 26 before putting in the green colour, some white substance (powdered sulphur in this case) is mixed instead of *hartal* as in 25. Of course it is possible to make a lac-stick with green colour alone, but it is not much used. I asked the artisan to bring me a specimen, and brought me stick 27. But even in this I discovered he had put some turmeric though only of the weight of 2 grains.

352. 28. *White.*—" The substance mixed here is powdered sulphur. In making white sticks a greater quantity of colour-substance is used than in the others, and similarly greater exertion is required in beating it and mixing it with the *chapra*. Before the final stroke of the hammer they also mix *biroza-i-chil* (*i.e.*, resin of **Pinus longifolia** 21). It is supposed to brighten the colour.

353. 29. *Black.*—" Here lamp-black is mixed with the *chapra*. The oil used is that extracted from *sarson*, a kind of mustard-seed (**Brassica dichotoma**).

354. 30. *Shingarf.*—" This colour is sold in the bazar (red oxide of mercury. So are *navrangi*, *i.e.*, orange-colour (31), *hirmazi*, a kind of red (32), and crimson (33), but in this last stick white powder (*i.e.*, ground-sulphur) is also mixed.

355. 34. *Lajwardi.*—" This is a very favourite colour. It is made from a combination of ground sulphur and *jamini* colour obtained from the bazar. The pure *jamini* colour (*i.e.*, colour resembling the fruit of **Eugenia Jambolana**) is shown in stick No. 35.

356. 36. *Chapra.*—" This is a stick made of *chapra* alone. It is not often used.

357. 37.—*Lakhi.*" This is the lac-dye, in the proper sense of the term, and is obtained by mixing *lakhi* (16*a*) with the *chapru* (19). As mentioned above, it is only in this stick that *lakhi* is used.

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Art Manufactures.

358. *Art Manufactures.*—" Hoshiarpur is one of the chief wood-producing districts in the Panjab, and as the function of dyeing diverse kinds of wooden furniture is performed with lac-sticks, there is a fair amount of lac-industry in the district. There is, however, no regular manufactory in the place, nor is the work carried on, on any very large scale. A shop here and a shop there, every artisan works at his own lathe in antique style, and all of them in pretty much the same way. The instruments used are very imperfect and tools very simple, and yet articles of exquisite taste in which colours are beautifully blended, are produced. Toys of various shapes are turned every day and find a ready sale in the market.

" The lacquer work here is done by the same men who do the turners' business and who are called 'Kharadias.' The chief varieties of lac work known as practised in the district are four:—

359. (*i*) *Ordinary Lakhi work.*

The Lathe.

" This is the ordinary plain work. A wooden article, say a box, is made to revolve on a lathe, which consists of two uprights made fast to the ground through which two iron spikes are fixed. On the pointed edges of these spikes the box is suspended from both sides and is made to rotate by means of a bow with a cord attached to it which is moved up and down like a piston rod by the turner. This rectilinear motion in the bow produces a curvilinear motion in the box; and while the rotation lasts, the turner goes on chiselling the box till it acquires the required shape. He then smooths it with, say, powdered brick, and when the article assumes a little glossy appearance it is revolved again, and a lac-stick of the required colour is pressed hard against it. The friction produced by rotation yields enough warmth to soften the stick Accordingly some colour melts off, and by rotation is made to spread all over the surface. A small stick of date wood **Phœnix dactylifera**, specimens 38 and 30 (39 used for the outside of a box, 38 for the inside) with a pointed edge is then rubbed over the coloured surface. This and the use of a little rag (for which the workman sometimes uses his own shirt sleeve) makes the colour look bright and evenly spread out.

" This plain coating of lac colour is generally done on legs of bedsteads excepting their tops on which work of the second class is usually done.

" I send two balls (No. 40) showing this plain colouring, the wood used is tahli.

360. (*ii*) *Abri work.*

" This species is only a variety of (i). It is called *abri*, because it possesses a motley appearance like the patches of an abr or cloud.

" I send a specimen box 41, the bottom part of which has been worked in this style which may be thus described: To begin with, a coat of yellow colour is given to the box, as the subsequent work comes out better on it than on the bare surface of the wood itself. Then a very small and thin pencil (No. 42) which is made like the specimen stick 37 (only with this difference that the wire of shell-lac is drawn out much thinner than in 37, so that the stick becomes rather hard and is not so easily liable to melt as the other), is pressed

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against the lathe in the manner described above, but the pressing here is not so hard and not uniform. The workman moves about his hand so skilfully that he scatters the colour wherever he chooses to do so. The red colour is thus spread out and in the blank spaces or yellow surface remains as it was before. A black stick of the specimen 29 (no thin pencils are used for black or any other colour excepting the red above noticed) is now pressed in the same skilful manner, and only fills in the small borders of the spaces left by the red stick. Lastly, white stick is used to fill up these spaces, so that not a vestige of yellow remains. The result is a mottled appearance which may be made to contain a sprinkling of as many colours as one chooses to have. Of course after the application of each new colour, there is the usual rubbing with date-wood, rag, brick-powder, and headings of wood-carving.

361. (*iii*) *Atishi work.*

" About three-fourths of the lacquer-ware in Hoshiarpur is of the third kind. It is called *atishi*, *i.e.*, fiery, because mild fire is constantly placed near the lathe when the work is being done, and some say because the article of this style gives a fiery glow when laid in the sun. I send three specimens of this work, one finished and two others showing the preparatory stages.

" *Cup* (43) exhibits five stages, which are marked on it—

a. Shows the ordinary wood ready for colouring on the lathe.

b. When this wood has been further polished by rubbing it with brick-powder, called *pipa* (specimen under cover 46), mixed with glue and water.

c. Some tin and glue are mixed together with great labour. This mixture is then applied on *b* with a rag and the result is *c*.

" A sample of this mixture is sent under cover (47) glue and tin are also sent marked (*a*) and (*b*). It is said that the right proportion of these elements for a good mixture is 2 tolas of glue in $\frac{1}{16}$th seer of (tin).

d. The fourth stage is practically the same as *c*, only the tin has been made brighter by rubbing it with a *mohra* (a kind of shell).

e. On the tin ordinary red lac-stick is pressed against the cup and the lac-colour is produced.

Cup (44).

" This shows further developments. On the red colour (as shown above under *e*) the artisan works with a pointed iron-bar which he calls his ' pen,' with this ' pen ' he engraves designs of flowers, leaves, etc. In this particular case a yellow lac-stick is then pressed against the surface of the cup with the result that the engraved parts become saturated with the yellow colour. It will be noticed that the petals of flowers on the cup are engraved or rather scratched inside. A *lajivardi* lac-stick (specimen 34) is then applied to the cup and the *lajivardi* colour adheres to these engraved places alone, and the result is shown in cup (45).

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Cup (45).

"The inside of the leaves is now engraved and green colour put in with the green lac-stick. The process may be repeated and other colours put on as one desires.

"It may be added that after the application of a fresh colour, *pipa* is rubbed over the surface of the cup to give it a polish. When the article is finished some mustard oil is also applied with a piece of rag in order to give it lustre and brightness.

362. (*iv*) *Naqshi work.*

"This work of pure engraving is not much in requisition here. It requires greater exertion and much more skill than the other three kinds mentioned above and owing to its comparative costliness is not much patronized.

"For specimen of this work I send one highly finished box (48) to be shown in the Museum. It is by no means the best that could be made here, as the artisan in this case (by name Jani) has been rather hurried on, as he had also to make the lac-sticks described above. In order to explain how such work is done, I must refer for a moment to the lid of box (41) on which various layers of lac-dye have been worked out by means of lac-sticks in the following order:—

Yellow or white, red, green and black.

"These layers on the box (41) have been opened a bit to show the different colours used.

"Now exactly the same arrangement of coloured layers has been effected on the box (48), the topmost layer being black. The workman then takes his 'pen' and works laboriously with it. With his patient engraving all the coats excepting yellow are opened. The yellow layer is used as a sort of foundation surface on which engraving is based. There is no design, no pattern, which the artisan keeps before him to copy. Yet his unaided fingers hardly make a false move, whether he works in the day or at night, as was the case in the preparation of box (48). In the centre of the lid there is a knob of ivory which gives the box a pleasing look."

II.—OTHER LAC MANUFACTURES.

363. There are several special industries in addition to turnery, where lac is extensively utilised. These have been incidentally mentioned in the opening remarks of this chapter but it may be desirable to deal more fully with one or two of these:—

364. ***Chúris or Bracelets.***—These are made mainly from the inferior qualities of lac, such as the *khud* or dust obtained on reducing stick-lac to seed-lac; the *gaud* or fine powder derived from the washings of seed-lac; and lastly the *kiri* or *phog*—the refuse

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obtained after the shellac, button-lac, etc., has been squeezed from the melting bags. These three products have to some extent separate properties and find distinct markets; but they may be dealt with in the present instance as if identical. The manufacturers of *churis* as a rule mix the *khud*, *gaud* or *phog* with one-third soft red clay and heat the clay and lac in a pot until they get completely mixed. From this they manufacture *churis* using a purer quality of lac to carry the colours and surface dressings. As the process differs considerably in the various provinces of India, the following passages will be found specially interesting :—

Bengal (Cuttack).

Passages taken from the Report on the Agriculture of the District of Cuttack, by Mr. N. N. Banerjee, *on the subject of Lac, page 173.*

365. The principal material of which *churis* are made is *jow* or lac. To three parts of dry lac, one of red earth of the fields is added, and both are put into a *handi*, or earthen pot, and set on the fire, and the mixture is constantly stirred with a stick until it becomes of the consistency of paste. The melted matter being well mixed, is then poured out on a flat wooden board, and when it has cooled a little, it is rolled with a wooden mallet into a stick. This stick or cylinder of prepared lac is then held up over a fire of coals kept for purpose in an earthen pan (*chhelua*), and as it softens by the heat, it is again rolled backwards and forwards on the board and reduced to the thickness of an ordinary wooden pencil. Pieces of the required size are then cut off from this thin stick of lac, and each piece is held up over the fire and the two ends of it are joined. This is then set on a conical framework of wood, seven to eight inches long, tapering from three inches in diameter at the base to two inches at the apex. To the centre of the cone is attached a cylindrical handle about 16 inches in length, which is held in the hand while the upper frame-work is made to revolve over the fire. The *churi* is thus moulded into shape, and is smoothed with the blade of a knife. When it cools and turns hard, it is taken out and another piece of lac is taken up and the process is repeated. When five or six are ready, they are again put on the frame and held over the fire, and when they have softened a little, the first and the last *churis* are given a round shape and the intermediate ones are flattened down with the knife. Finally, a coating of lac coloured red, yellow, green or blue, according to choice, is put on each *churi*; and while the frame is held over the fire the *churis* are polished with the blade of a knife, and with the edge each *churi* is cut and detached from its neighbours. A thread of lac is then put round the edges of each *churi*, and small bits of glass are set round the middle. The first and the last *churis* are covered over with *panni* or *rángá* (tinsel) to resemble silver. The *churis* are then ready for use. Coloured lac used for the coating is prepared in the following manner :—

Colours.

366. To three parts of lac, one of *hartal* is added to make the colour yellow. For a red colour one part *hinglu* (country vermilion)

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is added to three parts of lac, and for a blue colour one part of indigo is added to three parts of lac. Half of *hartal* and half of indigo added to three parts of lac give a green colour. The colouring matter is mixed with water and ground on a stone (*sil*) until reduced to the consistency of a thin paste. It is left in this state on the stone, while the lac with which it is to be mixed, having been placed in a piece of cloth, is melted over the fire until it becomes so liquefied that it can easily pass through the cloth, when it is held over the stone containing the colouring matter and allowed to fall out in drops on the paint. The whole is then mixed with two sticks, and becomes coloured lac, and is wrapped round a stick and allowed to harden. In this way it is kept ready for use. MANUFACTURE OF CHURIS OR BRACELETS.

Coloured lac thread, referred to above, is made by drawing coloured melted lac into thread with a stick. This thread is put on the *churi* round the edges and represents a raised border.

Passage taken from the Hand-book of the Manufactures and Arts of the Panjab, by B. H. Baden-Powell, Esq., *1872, page 242.*

367. Lac bracelets or churis "are made in many places, especially Delhi, and the process in the Panjab exactly resembles that described in a report on one of the Central Indian Districts, which I have unfortunately mislaid, but which I have used for the purpose of quoting the recipe for making the gold solution that gives the gold lustre to these pretty but fragile toys. Panjab.

368. "Refined or purified lac is mixed with the fine powder of burnt bricks, and the two are heated together in an iron pan and stirred till perfectly combined. The lac is drawn out into sticks of the thickness of the intended bracelet, and this is done by rolling the sticks on a flat board while still hot. Pieces of the requisite length are cut off and each piece is bent round and joined, and placed on a wooden cylinder to cool, and to be further ornamented. The glazing with gold solution and silvering is generally done before the sticks are cut up.

The Dewan of Jhallawar in a highly instructive note on the Lac Industry of that State remarks regarding the Churi trade:—

369. "The lac is most commonly used in Jhallawar in making *churis* (bangles for females). The material used for this purpose is prepared by mixing together equal quantities of lac and sand. At first it is made into thin sticks, or pencils of suitable lengths which are rounded off by being rolled between a smooth bat-like piece of wood and slab of stone, and are then made into the required shapes by somewhat similar process. The *churis* thus made are subsequently coloured in various ways. Sometimes gold or silver or tin leaves are applied to them in various pattern."

Chapri is also used in varnishing earthen pots.

(*l*) Lac is not employed in metal industry in this country.

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Extract from a communication received from the Prime Minister of Bandi State, No. 201 of the 16th February 1897 :—

370. "Bangles for women are also made of *chapri* with a mixture of little turpentine in it. *Chapri* is a preparation of lac, and is imported from abroad. Four sets of bangles are supplied as a sample, as also six pieces of *chapri* which comes from Bombay raw, and is dyed locally, and five *chapri* marbles and five cubes locally made up of *chapri*."

The use of turpentine may be remarked to be the chief point of interest in this passage.

The following account regarding the manufacture of lac bracelets is taken from the Bombay Gazetteer, Vol. III (Karia and Panch Mahals), pages 249-50 :—

Bombay (Karia and Panch Mahals).

371. "Before being used the powdered lac, *kanja*, is placed in a bamboo basket, mixed with powdered alum, washed with water, and for a day set to dry in the sun. Then it is ground to powder, melted in a metal pan, and in the proportion of two ounces to the pound (five *tolas* to one *seer*) mixed with brick dust and old powdered lac bracelets. The mixture is melted, poured on the ground, and rolled into a round flat cake. The cake is cut into three or four pieces, each piece heated and between two stones rolled into a stick, generally 5½ pounds in weight. The stick ready, some dearer lac is mixed with yellow orpiment, or red earth, or both, and made into small cakes from five to six ounces in weight. Then these yellow or red cakes are laid as an outside coating on the first lac-stick, in such a way as to make it all red or all yellow, or one side red and the other yellow. The end of the stick is then heated, drawn out, and then the proper length for a bracelet cut off. As they are formed, the bracelets are slipped over the oily conical head of a pestle-shaped tool known as the rice-pounder, *samela*. This has usually a head about ten inches long, varying in size from two inches across the top to four inches across the foot, and a handle about a foot and a half long. When the head has been covered with rings they are carefully heated, so that without melting the rings may stick to each other. This done, the set of rings is taken off, rubbed with brick powder, polished either with *copal* varnish or with a mixture of gumarine, *chandrus*, and linseed oil, and coloured vermilion, blue, or yellow.

372. "When the cylinder of bracelets has been coloured the next step is to print a pattern on them. For this purpose about two ounces of tin, *kathir*, are melted into a thin plate and rolled round a small ball of glue The ball is then set on a stone and for a whole day hammered by two men, the particles mixing together till they form a dull-grey metallic plate. Nextd ay the plate is broken into pieces thrown into a copper vessel with a little water in it, and placed over a slow fire. The plate gradually melts leaving a sediment sometimes strained off through a coarse cloth. The water is now ready for use. Meanwhile a little very fine cotton wool is tightly wound round a small bamboo chip and so wetted and pressed that it makes a pad or

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stamp hard enough to have a pattern graven on its face by a large iron needle. This cotton stamp is now taken, dipped in the tin-water, being very lightly pressed on the cylinder of bracelets, prints its pattern on their varnish. After printing the bracelet the cylinder is varnished once a day for three days, the varnish turning the white markings of the tin pattern into a beautiful gold. Then the pattern is completed by studding the bracelet with drops of tin-water coloured red with vermilion or white with chalk. A final coating of varnish finishes the work. When they are to be sold the bangles are separated from each other by a knife-like tool. Each bangle is then cut, passed over the wearer's hand, and the end melted and joined. The bracelets are sold two for $\frac{3}{8}$*d.* (a *pice*) generally in sets of twenty-five for each hand. They are generally worn by the *Vánia* women of Malwa, and by *Dohad* women of the Rajput, Patelia, and Rávalia castes.

373. "These lac bracelets are an imitation of the costly ivory Ratlám bracelets, of which a woman generally gets one set at her marriage, wearing them only on very great occasions. Besides bracelets, yellow and red striped armlets, *goliás*, are worn between the elbow and the shoulder. Except that they have neither varnish nor pattern, these are made in the same way as the bracelets. Two of them sell for $\frac{3}{8}$*d.* (a *pice*). The manufacture of lac bracelets gives employment to a special class of craftsmen called Lákhárás. Of these six families are settled at Jhalod and nine at Dohad. About half of them are Musalmans and half Hindus."

The following further passage from the Bombay Gazetteer (Nasik), Vol. XVI, page 180, may be regarded as instructive. Bombay.

374. "Lac working gives employment to a small number of Musalmans who form a separate community, known as Lakháris. They are chiefly found in Nasik, Malegaon, and Chandor. The raw material is generally bought from Bohoris, or native stationers, who get it from Bombay. Besides lac they require other pigments, vermilion, orpiment, indigo, and copper leaf, which also they get from the Bohoris. The process is to mix a certain amount of cheap sealing wax with brick-dust, and heat it till it becomes thoroughly pliable. It is then made into a stick, about an inch in diameter, and from one to two feet long. Next it is covered at one end with a layer of lac coloured red, yellow, green, or blue, by mixing with it mechanically such pigments as vermilion, orpiment, and indigo, or if green is wanted, a mixture of orpiment and indigo. The end thus covered with coloured lac is then heated and drawn out. When the coloured end becomes as small as a quill, it is cut away from the stick, and, while still hot, it is stamped by a carved brass or wooden mould. It is next wound round a wooden cylinder and the ends heated and joined, and, finally, to make it lie in one plane, it is laid on a stone slab, covered with a flat piece of wood, and struck lightly with a hammer.

375. "The lac-worker uses six tools. The rolling pin, *saila*, to roll the heated lac into a stick, worth 6*d.* (4 *annas*). A stone, which must be flat and is generally a piece of a broken grinding mill. The stone is heated and the lac softened on it and rolled into a stick. The cost Tools.

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is nominal. A hammer worth 6*d.* (*annas.* 4). Two *thasás* or many-sided wooden or brass moulds with different designs carved on each face, each mould costing from 16*s.* to £1 (R8 –R10). The *sácha* or wooden cylinder, round which the wax is wound to give it the shape of a ring. The *tháppa*, or flat piece of wood, with which the lac ring is pressed to make it lie in one place.

376. "The only articles made are lac bracelets. The maker generally disposes of them to the Kásárs, or bangle-sellers, selling them at from ¾*d.* to 1½*d.* (½ –1 *anna*) each. They are worn by Hindu women of all classes. Nasik lac bracelets have no special merit, and are not in much demand.* The workmen are poor, even with the help of their women, they do not earn more than from 8*s.* to 12*s.* (R4—R6) a month."

MANUFACTURE OF VARNISH.

377. ***Varnish.***—Lac may be said to be one of the most extensively used ingredients in the so-called "spirit varnishes"; but in order to give tenacity and elasticity to these some of the softer resins, such as elemi, mastic, Canada balsam or Venice turpentine, are indispensable ingredients. The spirit evaporates and a fine coating of lac and resin is left behind which constitutes the polish or varnish. This is, however, when lac only is used, liable to crack on exposure to the air. It is probably from a similar reason that in the better class lac-turnery, the finishing polish is given with an oil, such as linseed or sesamum. The "oil varnishes" differ from the spirit varnishes mainly by the fact that they dry through a chemical change taking place in the oil which oxidised into a tough glossy film.

378. As already stated (paragraph 1), reference is made in the Ain-i-Akbari (1590 A.D.) to the lac-varnish to be used on houses and furniture. The knowledge in this substance is, therefore, by no means a modern one with the people of India. In Europe and America lac-varnishes are often coloured and in that condition are extensively used for metal-work, for imitation gilding and bronzing and for staining timbers. Lac dissolved in alcohol and coloured with gum-gutta or saffron, etc., may be used as a varnish to impart a gold appearance to metals while not obscuring their brightness. Mr. Baden-Powell in his Panjab Products appears to have been one of the earliest Indian authors to draw attention to the gold-coloured varnishes used in this country. His account has been republished by various writers and the story told in different language, but the facts remain the same. The following is Mr. Baden-Powell's original passage in which he deals with the application of this art to the manufacture of *churis* (lac bracelets):—

379. "To silver the sticks, tin leaf or foil is mixed with half its weight of dry glue, and these are pounded and ground together for a

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MANUFACTURE OF VARNISH.

long time, till in about six hours' time they amalgamate. The mass is then thrown into very hot water, when it crumbles into little pieces. They then stir this up and pour off the water, repeating the operation till all dirt and impurity in the water disappears. When the solution is quite pure, they boil it up and let it stand, carefully covered, for the night.

380. "Next day the silver solution is found deposited. This is spread with a brush on the lac, and burnished by rubbing over with strings of glass beads. If it is desired to produce the effect of gold, the silvered lac is painted over with a transparent yellow varnish prepared as follows :—

381. "Gum myrrh (*bol*) is boiled in sweet oil in proportion of 40 to 48. The liquid is strained through a cloth; the sediment thrown away and the oil set aside. An earthen pot is now smeared with clay on the underside, and its mouth is closed up with an earthen cover, the edges of which are luted over with clay, so as to render it air-tight. This is heated red-hot over a fire. When quite red, the mouth is opened and little bits of *sundras* (copal) are thrown in. The same weight of *sundras* as of *bol* is used; the mass is stirred and the mouth again closed. The stirring and heating are repeated till the copal is thoroughly reduced. The myrrh and oil solution is now added to it, and the whole heated and stirred, after this the mixture is strained through a cloth and is ready for use. The lac bracelets are often further ornamented by having little glass beads and bits of tin foil stuck along the edge."

Passages taken from the Cyclopædia of India and of Eastern and Southern Asia, by Surgeon-General Edward Balfour, *pages 649—651, 1885.*

382. Lacquer, a varnish either for wood or for brass, made with shell-lac and spirits of wine. Hard-wood lacquer may be in the proportion of 2 lbs. of lac to the gallon. Another recipe is 1 lb. of seed-lac and 1 lb. of white rosin to a gallon of spirits of wine. For brass, the proportions are ½ lb. of pale shell-lac to 1 gallon of spirit. It should be made without heat, but simply by agitation for five or six hours. It should then be left until the thicker portions have subsided, when the clear lacquer must be poured off, or, if not sufficiently clear, it must be filtered through paper. It darkens by exposure to light, so that paper should be pasted round the bottle to exclude it. A pale-yellow lacquer may be prepared from 1 oz. of gamboge and 2 oz. of cape aloes, powdered and mixed with 1 lb. of shell-lac. For a full yellow, ½ lb. of turmeric and 2 oz. of gamboge; for red lacquer, ½ lb. of dragon's blood and 1 lb. of annatto. The colour, however, is modified by that of the lac employed. Lacquers may also be coloured

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by dissolving the colouring matters in spirits of wine, and adding the proper proportions of these to the pale lacquer, according to the tint required. Mr. A. Ross prepared lacquer with 4 oz. of shell-lac and ½ oz. of gamboge, dissolved by agitation in 24 ounces of pyro-acetic ether. The clear liquor is decanted, and when required for use is mixed with eight times its volume of spirits of wine. Hard-wood lacquer is applied nearly in the same manner as French polish. In lacquering brass, the work must be cleansed from grease and oil, and if convenient, heated to the temperature of boiling water, when the spirit evaporates and the varnish attaches itself more firmly to the metal, producing a brilliant effect. If heat cannot be applied, the air should be dry and warm. The lacquering should follow immediately after the work is polished, otherwise it will become tarnished, and prevent the lacquer from adhering.

MANUFACTURE OF SEALING WAX.

3. *Sealing-wax, Lac-toys, Lac-mats, Lac-paper, Lac-dye Ink, Lac and Sand whetstones, etc.*

383. *Sealing-Wax.* – Mention has already been made of the fact that certain articles are manufactured entirely of lac. The most generally known example of this nature is of course sealing-wax. This is prepared from any quality of lac up to the purest shell-lac. It is mixed with rosin to lower the melting point. All the poorer qualities of sealing-wax are of course made of the waste lac, such as *phog*, and they are coloured with the ordinary pigments. It is stated by Indian makers that the alizarin reds yield green sealing-wax and that the reds commonly met with have been produced with red-oxide of mercury.

384. *Variegated Coloured Marbles.*—Sir George Birdwood gives the following brief account of the manufacture of marbles, rulers, etc., of mixed colours:—

"The variegated balls and sticks are made by twisting variously coloured melted sealing-wax round and round a stick or ball from top to bottom in alternate bands. Then the stick or ball is held before the fire, and with a needle or pin short lines are every here and there drawn perpendicularly through the bands of sealing-wax, drawing the different colours into each other, when the stick or ball is rapidly rolled on a cool, smooth surface, and that intricately variegated effect is produced which is so puzzling until explained."

The same writer gives the following brief notice of the lac-mats—a speciality of South India:—

385. *Lac-Mats.*—"The netted mats are made by allowing the thread of sealing-wax twisted round a stick to cool, and then drawing off the whole coil, and breaking it into sections of three or four turns each, which are linked together into 'mats' of all sorts of variegated

colours, but chiefly scarlet and black, and black and golden yellow. I describe the process from actual observation."

MANUFACTURE OF RULERS MARBLES AND MATS FROM LAC.

386. *Ink.*—In a report received from the Political Agent, Haraoti and Tonk. Deoli, No. 1664 of the 7th October 1896, mention is made of lac being used "for making fast colour ink used in writing documentary papers. It is unfortunate that full particulars have not been afforded regarding this ink, but these may doubtless be afforded at some future occasion, when enough information may have been procured to justify a future note on this subject. It is believed that lac-dye is extensively employed as a red ink, and it is well known that shell-lac as an important ingredient in lithography both in India and all other parts of the world.

INK FROM LAC-DYE.

387. *Lac-leaf.*—A full account of the preparation of lac-leaf will be found (p. 324) in the article contributed by the Assistant Commissioner, Hoshiarpur. Lac-leaf is extensively used by the natives of India in their tinsel ornamentations.

LAC-LEAF.

388. *Whetstones.*—These are made in most provinces. The best quality of shellac available is melted in a pot over the fire and intimately mixed with an equal weight of the purest river sand. When intimately mixed and fussed together the molten mass is beaten into the shape and thickness of a whetstone. Similarly, a preparation of lac and sand is used to fasten sword and knife blades into the hafts. The turner also employs hardened lac as a temporary means of fastening articles to be turned on the lathe.

WHETSTONES FROM LAC AND SAND.

389. *Blow-pipes.*—Mr. H. Z. Darrah, formerly Director, Department of Agriculture, Assam, wrote :—

LAC-COATED BAMBOO BLOW-PIPES.

"This is a curious article made by one Muhammadan of Sylhet. The pipe is of bamboo and lacquered with effective colours. The arrows, 100 of which are sold with each pipe for R3-2-0, are made of small strips of bamboo, 8 or 9 inches long, tipped with iron and winged with an inverted cone of paper."—*Reports on Artware of India (1885).*

PIGMENTS USED IN LAC-TURNERY.

PIGMENTS USED IN LAC-TURNERY.

390. The following series of jottings, compiled province by province, gives the chief facts known regarding the tinctorial reagents used in India along with lac.

391. ***Assam.***—"*Composition of lacquer colours.*—The art of manufacturing lac-wares seems to be dying out in Assam. Sibsagar and

Assam.

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by dissolving the colouring matters in spirits of wine, and adding the proper proportions of these to the pale lacquer, according to the tint required. Mr. A. Ross prepared lacquer with 4 oz. of shell-lac and ½ oz. of gamboge, dissolved by agitation in 24 ounces of pyro-acetic ether. The clear liquor is decanted, and when required for use is mixed with eight times its volume of spirits of wine. Hard-wood lacquer is applied nearly in the same manner as French polish. In lacquering brass, the work must be cleansed from grease and oil, and if convenient, heated to the temperature of boiling water, when the spirit evaporates and the varnish attaches itself more firmly to the metal, producing a brilliant effect. If heat cannot be applied, the air should be dry and warm. The lacquering should follow immediately after the work is polished, otherwise it will become tarnished, and prevent the lacquer from adhering.

MANUFACTURE OF SEALING WAX.

3. *Sealing-wax, Lac-toys, Lac-mats, Lac-paper, Lac-dye Ink, Lac and Sand whetstones, etc.*

383. *Sealing-Wax.*—Mention has already been made of the fact that certain articles are manufactured entirely of lac. The most generally known example of this nature is of course sealing-wax. This is prepared from any quality of lac up to the purest shell-lac. It is mixed with rosin to lower the melting point. All the poorer qualities of sealing-wax are of course made of the waste lac, such as *phog*, and they are coloured with the ordinary pigments. It is stated by Indian makers that the alizarin reds yield green sealing-wax and that the reds commonly met with have been produced with red-oxide of mercury.

384. *Variegated Coloured Marbles.*—Sir George Birdwood gives the following brief account of the manufacture of marbles, rulers, etc., of mixed colours:—

"The variegated balls and sticks are made by twisting variously coloured melted sealing-wax round and round a stick or ball from top to bottom in alternate bands. Then the stick or ball is held before the fire, and with a needle or pin short lines are every here and there drawn perpendicularly through the bands of sealing-wax, drawing the different colours into each other, when the stick or ball is rapidly rolled on a cool, smooth surface, and that intricately variegated effect is produced which is so puzzling until explained."

The same writer gives the following brief notice of the lac-mats—a speciality of South India:—

385. *Lac-Mats.*—"The netted mats are made by allowing the thread of sealing-wax twisted round a stick to cool, and then drawing off the whole coil, and breaking it into sections of three or four turns each, which are linked together into 'mats' of all sorts of variegated

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colours, but chiefly scarlet and black, and black and golden yellow. I describe the process from actual observation." MANUFACTURE OF RULERS MARBLES AND MATS FROM LAC.

386. *Ink.*—In a report received from the Political Agent, Haraoti and Tonk. Deoli, No. 1664 of the 7th October 1896, mention is made of lac being used "for making fast colour ink used in writing documentary papers. It is unfortunate that full particulars have not been afforded regarding this ink, but these may doubtless be afforded at some future occasion, when enough information may have been procured to justify a future note on this subject. It is believed that lac-dye is extensively employed as a red ink, and it is well known that shell-lac as an important ingredient in lithography both in India and all other parts of the world. INK FROM LAC-DYE.

387. *Lac-leaf.*—A full account of the preparation of lac-leaf will be found (p. 324) in the article contributed by the Assistant Commissioner, Hoshiarpur. Lac-leaf is extensively used by the natives of India in their tinsel ornamentations. LAC-LEAF.

388. *Whetstones.*—These are made in most provinces. The best quality of shellac available is melted in a pot over the fire and intimately mixed with an equal weight of the purest river sand. When intimately mixed and fussed together the molten mass is beaten into the shape and thickness of a whetstone. Similarly, a preparation of lac and sand is used to fasten sword and knife blades into the hafts. The turner also employs hardened lac as a temporary means of fastening articles to be turned on the lathe. WHETSTONES FROM LAC AND SAND.

389. *Blow-pipes.*—Mr. H. Z. Darrah, formerly Director, Department of Agriculture, Assam, wrote :— LAC-COATED BAMBOO BLOW-PIPES.

"This is a curious article made by one Muhammadan of Sylhet. The pipe is of bamboo and lacquered with effective colours. The arrows, 100 of which are sold with each pipe for R3-2-0, are made of small strips of bamboo, 8 or 9 inches long, tipped with iron and winged with an inverted cone of paper."—*Reports on Artware of India (1885).*

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PIGMENTS USED IN LAC-TURNERY.

390. The following series of jottings, compiled province by province, gives the chief facts known regarding the tinctorial reagents used in India along with lac.

391. ***Assam.***—"*Composition of lacquer colours.*—The art of manufacturing lac-wares seems to be dying out in Assam. Sibsagar and Assam.

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Sylhet are the only two districts where the art is still practised. In Sibsagar the following colours are used. They are prepared by mixing shellac with the substances noted against them, respectively :– (1) yellow with orpiment, (2) red with vermilion, (3) blue with indigo, and (4) black with lamp-black fine charcoal obtained by burning the dry shell of a bottle-gourd (*Lagenaria vulgaris*). In Sylhet, a larger assortment of colours is in use. These are :—(1) sky blue (*asmani*) obtained by mixing powdered indigo and sulphur with shellac, (2) red by mixing lac with vermilion, (3) violet, with violet powder, (4) grey, with white lead, (5) brick red, with red resin, (6) orange with vermilion and orpiment, (7) dark green, with green powder, (8) green with indigo and orpiment, (9) black, with lamp black, and (10) yellow, with orpiment. The violet and green powders are presumably imported and of mineral origin. It is not known what red resin is."

N.-W. P. and Oudh.

392. ***North-West Provinces and Oudh.***—From Agra (letter No. 3630, dated 6th June 1896) the following extracts may be given of the pigments used in that district :—

Quantity of lac used.	Articles mixed for producing colours.	Proportion of colour sed to one seer of lac.	Colours produced.	How lac and colouring substances are mixed.
(1) One seer	Vermilion or Shingraf.	½ of a seer	Red.	By melting 1 and 2 together.
(2) Do.	Orpiment or Hartal	do.	Yellow.	By slightly melting the lac and beating it with a stone hammer on a piece of stone spread over with the colouring substance of the required colour.
(3) Do.	Indigo or Nil and sometimes charcoal of Babul tree.	do.	Black.	
(4) Do.	Indigo or Nil and orpiment or Hartal in equal parts.	do.	Green.	
(5) Do.	Indigo or Nil and white-lead or safeda.	do.	Light indigo and if safeda is not mixed deep indigo	
(6) Do.	Gulal, the red mixed powder used during the Holi ceremonies and obtained from Benares.	do.	Gulali or Scarlet.	

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Panjab.

393. ***Panjab.***—The following passages may be given under this heading :—

394. ***Shahpur.***—The lacquered wood turnery of Sahiwal differs from that of other places in being more crude in colour and simpler in execution. A particularly unpleasant aniline mauve is used ; but there is a better class of vases, platters and toys made in two colours, red and black, or red and yellow, or black with either. The scratched patterns are bolder and larger than elsewhere and many toys, *e.g.*, children's tea-sets, are finished in transparent lac only, the colour and grain of the wood showing through. Chess-boards with chess-men and a large variety of toys of forms that might puzzle an English child, are made at very cheap rates, but they do not seem to be as popularly known as they deserve to be.—(*Panjab Gazetteer*, *Shahpur District, 1897, page 188.*)

395. An exceedingly interesting report regarding the district of Hoshiarpur has been given in its entirety since it was found impossible to break it up into sections corresponding to the chapters of this review. The remarks regarding the pigments used in that district should therefore be read (p. 326) in this connection.

Report on manufacture of Wooden toys, etc., furnished by the Depuy Commissioner, Dera Ghazi Khan, Panjab, with letter No. 580 L. F., dated 16th December 1896.

396. "Toys, circular boxes and other such articles prepared by artisans of the Jampur and Dera Ghazi Khan Tehsils in this district are generally made of *shisham* wood (**Dalbergia Sissoo**). Large and small blocks of *shisham* are kept ready for use ; and after removing the bark and outer surface of the wood are shaped into the different articles required which are then turned on a lathe (*kharad*) to assume their proper forms and get coloured, wholly or partly as the case may be, with plain or tinted lac. The red colour is produced by adding cinnabar and vermilion (bisulphide of mercury) to melted lac ; yellow colour by adding orpiment or yellow arsenic (bisulphide of arsenic) called *hartal ;* green by adding a mixture of yellow arsenic and indigo blue ; and black by adding lamp-black or soot to melted lac in the same way. The golden colour is developed by using chloride of tin which is then covered with lac. The process adopted is invariably the same, *viz.*, bits of plain or tinted lac are attached or stuck on to a straight piece of wood with which the coatings are turn by turn given, while the article is once more being whirled in the lathe. Some of the articles are finished by removing the colour in parts and filling the gaps with an amalgam of mercury and tin, or are carved to insert bits of ivory of different shapes."

Extract from letter No. 938, dated the 24th December 1896, from the Deputy Commissioner, Shahpur, Panjab.

397. "Colour sticks are used by wood-turners to colour their ware when the turning process is finished. The sticks are made of shell-lac

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melted down and coloured by various simple and compound colours as described below, or they are made of shell-lac mixed with pounded aniline colours imported from Europe :—

(*a*) Yellow—Is prepared by mixing melted lac in the proportion of $2\frac{1}{2}$ chittacks to $1\frac{1}{2}$ chittacks of orpiment (Sulphide of arsenic).
(*b*) Green—Is prepared by mixing $\frac{1}{4}$ chittack common oil to the yellow colour as above described.
(*c*) Red—Is prepared by mixing 3 chittacks lac with 1 chittack of sulphide of mercury.
(*d*) White--Is prepared by mixing one chittack shell-lac with $1\frac{1}{2}$ chittacks of white lead (carbonate of lead).
(*e*) Black—Is prepared by mixing lamp-black with lac.
(*f*) Sharbati or lac colour—Is made by mixing a quantity of shell-lac with *baroza* (= rosin of **Pinus longifolia**)."

Rajputana.

398. ***Rajputana.***—Rao Bahadur P. Sukdeo Prashad, Judicial Secretary to the Masahib Ala of Marwar, in a long and interesting report on every aspect of the lac trade and industries of that State, furnishes the following particulars regarding the pigments employed :—

"Before the introduction of European pigments (aniline) only fast colours made of country materials were used, but now this is not the case. The ordinary aniline colours sold in the bazars are mixed with the lac and used. It is a fact that the new colours are very deep and are generally liked by the public.

"The following pigments are commonly used :—

No. 1.—Lac called *chapri.*
No. 2.—*Hartal* orpiment.
No. 3.—Broken bangles of lac (lac and sand mixed, called *aster,* or the inner layer of colour 1 tola lac heated mixed with 5 tolas of sand make these bangles).
No. 4.—Lamp-black.
No. 5.—*Hinglu (Shingraf)* cinnabar.
No. 6.—*Bahu-ka-guli.*
No. 7.—Red colour *(Lal naya rang)* (= new red colour).
No. 8.—Green *(Sahz naya rang)* (= new green colour).
No. 9.—*Sasui* (molet), a bluish colour."

399. "The following combinations of these form the battis of coloured lac-sticks used by the turners :—

"No. I *Shingraf* stick or *batti*—8 tolas of lac are heated on charcoal fire for 15 minutes, half of which is made in the form of a cup with which 3 tolas of *Hinglu* (No. 5) with 3 mashas of *water* are put and the other half of the lac is put on the cup and the whole is then heated on the fire till the required colour is obtained.

"No. II Yellow stick—3 tolas of *hartal* (No. 2) is heated with 1 tola of lac and well beaten by two men for one hour, after this

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another 1 tola of lac is mixed, heated and beaten. *Water is not used* in mixing.

"No. III Green stick—It is made of yellow (*without water*) No. II and the green colour (*Naya rang*) as to proportions, when the yellow colour is prepared half of it is kept and only $\frac{1}{4}$ ratti of green is mixed with it.

"No. IV Black stick—2 tolas lac and half tola of *Bahu-ka-guli* (No. 6) with *water* are mixed and are heated on fire and beaten. No. 2 (*a*) Yellow (with water) 6 tolas *hartal* were ground with water and mixed with 12 tolas of heated lac.

"No. III(*a*)—Green stick (*with water*) half of the No. II (*a*) is mixed with green colour and is heated on fire and beaten.

"No. V Red stick—One tola colour *with water* is mixed with 8 tolas of lac and heated on fire till the required colour is obtained.

"No. VI Violet stick—6 tolas of lac are mixed with half tola of sosni colour with *water* and is heated on fire.

"No. VII Astar stick—8 tolas of bangles No. 3 and 6 tolas of lac are mixed and heated on fire. No. IV (*a*), Black 4 tolas of lac and $\frac{1}{2}$ tola of lamp-black and heated on fire.

"No. VIII stick—Lac only heated.

"No. II. (*a*) Yellow (*with water*) is used as a first layer of colour except in the case of very smooth surfaced wood.

Alternate use of water battis with others.

"No. VII. *Astar* (lac and bangles of lac) is used as second layer.

"All other colours are done after these two layers have been finished. In order to equalize the colour, the fruit stalk of palm tree is rubbed against the wood on the revolving lathe and the leaf blade is similarly used in the case of fine lines only. The finishing touch is given by *til* seed oil being rubbed by a piece of cloth against the wood on the lathe.

"No. II Yellow and No. III Green, both *without water*, are used where their lines are made over other colours."

400. Babu Durga Pershad Hakim furnished an instructive note on the Lac Industry of Indergarh in the Kotah State, Rajputana. The following passage may be here given from which it will be seen that aniline dyes are now-a-days most unfortunately being largely employed in the production of the highly artistic art-turnery for which that town is famous :—

401. "The following are the pigments used in preparing the coloured lac sticks used by the turners :—

1. Lac, uncoloured (heated and unheated). 2. "*Safeda*" (heated and unheated) known locally as white lac of European manufacture. This cannot be prepared locally; sticks of it are purchased at Indergarh for 5 or 6 annas a piece; 3. "*Neel*" (indigo); 4. "*Baigni*" (aniline purple of European manufacture); 5. "*Gulabi*" (aniline rose of European manufacture); 6. "*Hara*" (aniline green of European manufacture); 7. "*Hingloo*" (vermilion); 8. "*Hartal*" (orpiment); 9. "*Kajal*" (lamp-black).

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"All the above are obtainable in any Indian bazar, and the coloured sticks are prepared by the artisan himself by mixing them with heated pure shell-lac or white lac in the following preparations :—

10. Yellow—Shell-lac and *hartal*; 11. Black—Shell-lac and *kajal*; 12. Blue-black—Shell-lac and indigo; 13. Red—Shell-lac and vermilion; 14. Purple—White lac and European purple; 15. Rosy—White lac and European rose colour; 16. Sky blue—White lac and indigo; 17. Dark green—Shell-lac, indigo and *hartal*; 18. Green—Shell-lac and European green (aniline).

"The ingredients are apportioned according as to whether the colour required is to be light or dark. Of late years, European colours have been imported owing to their cheapness; they are supplanting the colours locally produced and are everywhere obtainable.

"There are only four artisans at Indergarh and they content themselves with making sufficient for their daily needs. No stock of lac wood-work is kept, and there is no export trade. With a demand for export this trade would develop."

Bombay and Sind.

402. ***Bombay and Sind.***—The Collector of Haidrabad, Sind, in his letter No. 3325, dated 23rd July 1896, furnishes the following particulars regarding the pigments used by the lac-turners of that district :—

"The ingredients for colouring, etc., generally used in the manufacture besides lac are orpiment, vermilion, indigo, *dhup*, a preparation of resin, brimstone, and a green paint imported from Europe. A small quantity of each of these ingredients is sent herewith, together with a stick of uncoloured lac, as well as a few sticks of coloured lac illustrating each colour used in the industry. Coloured lac is made by mixing the colouring ingredient which is first reduced to powder with plain lac and heating the mixture over fire. Lac mixed with orpiment in the above manner produces a yellow, when mixed with vermilion it produces red, and so on. The green colour inside and underneath the box is done by hand."

Madras.

403. ***Madras.***—The following information has been communicated by Mr. Edgar Thurston, Superintendent of the Government Museum, under cover of his letter of the 7th April 1896 :—

"A small quantity of sample uncoloured lac is taken. Dust, etc., removed from it. Then a small quantity of sample C *(Nattu arithalam)** is taken and very finely powdered, a little water is then added to it and mixed so as to get a thick consistence. Then fire

*This from the description would appear to be yellow arsenic = orpiment.—G. WATT.

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is kindled with charcoal in a broad-mouthed chatty in the way goldsmiths do for their work. Then the lac is melted. This is done in the following way:—In a stick a little of the lac (*areul arrakku*) is touched and held before fire. This begins to melt and becomes adhesive. Then a little more of the lac is dipped in it and held before fire, and when it begins to melt another stick is taken, and by rubbing the sticks one over the other the lac is melted. The lac must not be allowed to fall in fire while melting. It is for this purpose that sticks are used to keep the lac on them. This process is repeated until all the lac has been melted. Then these sticks are dipped in the colour which has been prepared of sample C (*Nattu arithalam*) little by little, and by holding before fire the lac and the colour are well mixed while melting by rubbing the sticks one over the other. When it has been mixed well and while hot the coloured lac is removed from the sticks and made into a round mass and shaped into sticks like sealing wax. After a little while it becomes hard.

"Red, green and blue coloured lac are made in the same way as above described. Sample D being used for red, sample E mixed with a little of sample C for green and F for blue colours."

404. Process for manufacturing of coloured toys—

"The wood that is to be turned is cut into log and fixed in the lathe. This is simply two long pieces of wood, to each of which a sharp-pointed iron is fixed to hold the wood that is to be turned between. When the wood has been fixed it is made to revolve by passing round it at one end of a string which is tied to a bamboo in the shape of an arch like a bow. While the wood is revolving the chisel is applied to its surface in whatever way the wood is to be turned. The chisel scrapes the wood to the shape required, and before removing the article from the turning machine, sticks of coloured lac are pressed against its surface as it revolves. The friction melts the lac which adheres to the surface in an unpolished stage. Then a leaf, called *Thalanalai* (sample B) in Tamil, is pressed against the coloured surface. This gives polish to the colour."

TIMBERS USED IN LAC-TURNERY.

TIMBERS USED IN LAC-TURNERY.

405. As already explained, one of the objects of the enquiry into the subject of lac-turnery was to discover the timbers used for that purpose, from the idea that these might also be found suited for the production of bobbins. The numerous cotton, jute and wool mills that are scattered all over India have to import enormous qualities of bobbins annually. A correspondent (on his being asked for information as to the Indian timbers suitable for bobbins) remarked that he had ascertained in Madras that bobbins of a certain size were regularly procurable at the ridiculously low price of R24 per gross; he was accordingly of opinion that it could not pay to compete. But

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if it pays an importer to dispose of bobbins at the price or any other price, the opinion generally held is that it should still more pay a maker to produce them in India, provided he can obtain suitable timber in sufficient abundance and at a remunerative price. This view of the case has at all events been entertained by at least three separate merchants who have each affirmed that they are willing to import the self-same machinery as used in the bobbin trade of Europe and to start factories on a large scale, provided they can get satisfactory evidence as to the one difficulty—the timber supply. The observations recorded in this paragraph, it is hoped, may, therefore, prove of some value to those interested in the bobbin trade as well as to those solely concerned with lac-turnery.

406. The following alphabetical enumeration has been framed from all the replies to hand during the past four years—the passages dealing with this subject having accordingly been omitted from the letters quoted in other chapters of the review. It is believed, however, that this mutilation will not materially lessen the value of the contributions that have been received, seeing that the list that follows gives the names of the chief localities where the timbers in question have been recorded as used in lac-turnery.

407. I would, however, here explain that in only rare instances were botanical specimens furnished along with the letters or samples of woods received. I have had accordingly to accept the names (scientific or vernacular) given me as correct or to arrive at these from comparison of the timbers contributed with those already in the Museum. In this connection I would, for example, mention *Khirni*, *Khirini* or *Khirna*, one of the most widely used of all timbers. In some instances the samples to hand have borne one or other of these vernacular names accompanied with **Wrightia tinctoria, Mimusops indica,** and **M. Kauki** as the corresponding scientific name. I believe that most, if not all, the timbers in question are **Wrightia tinctoria,** but I have preferred to give the other scientific names as well because of their having been specially mentioned :—

Acacia arabica, *Willd.* (Leguminosæ), the *Kikar* or *babul* of Hoshiarpur, Shahpur, etc. In Jaipur it is especially mentioned as suitable for Indian clubs—*Mugdars.*

A. Catechu, *Willd.*, the *Hair* of Hoshiarpur; Jaipur mentions it as used for the feet of *charpoys* and *musals.*

A. modesta, *Wall*, the *Phulah* of Hoshiarpur.

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Adina cordifolia, *Hook. f.* (Rubiaceæ), the *Haldu* of Saharanpur; the *Aladran* of Surat where it is said to be largely used for cradles (*palnas*), etc.

Ailanthus excelsa, *Roxb.* (Simarubaceæ), used in Jaipur for scabbards, etc.

Albizzia Lebbek, *Benth.* (Leguminosæ) the *Shrin* of Shahpur.

Anogeissus latifolia, *Wall.* (Combretaceæ), the *Dhau* of Marwar.

Artocarpus Chaplasha, *Roxb.* (Urticaceæ), the *Sam* of Assam.

A. integrifolia, *Linn. f.*, the Jack-fruit trees, Assam.

Anthocephalus Cadamba, *Miq.* (Rubiaceæ), the Kadan is in Alwar used for toys, bottles, jugs, etc.

Bauhinia latifolia (Leguminosæ), the Jinja of Marwar.

Bombax malabaricum, *DC.* (Malvaceæ), the *Semul* is in Ulwar used for boxes, packing cases, toys, scabbards, fishing floats, linings of well, etc.

Borassus flabellifer, *Linn.* (Palmæ), the *Tala* or Arna according to Dr. Hendley is in Jaipur used to make painted animals. It is a soft and weak wood but can be worked easily.

Boswellia thurifera, *Roxb.* (Burseraceæ), is the *Salar* wood of Jaipur is especially used in making *hooka* pipes or *nechas*.

Cassia Fistula, *Linn.*, (Leguminosæ), the *Sonaru* of Assam.

Cedrela Toona, *Roxb.* (Meliaceæ), the *Tun* of Saharanpur, Hoshiarpur, Dera Ghazi Khan and Shahpur.

Cordia Myxa, *Linn.* (Boraginaceæ), is in Jaipur known as *Gondi* and it is said to be used for *hooka* shafts.

C. Rothii, *R. & S.*, the Gundi of Marwar.

Dalbergia Sissoo, *Roxb.* (Leguminosæ) the *Shishan* of Saharanpur; the *Tahli* of Hoshiarpur is mentioned in connection with Jaipur as good for opium boxes, charpoy legs, chilums and *sulphis* (datura-flower-shaped chilums). In Ulwar it is stated this wood is used for all sorts of furniture and turnery.

Eugenia Jambolana, *Lam.* (Myrtaceæ), *Jamun* wood is in Jaipur mostly used for *nechas* or smoking pipes, *Chilum-ki-nalis* (tobacco pipe-stems).

Gmelina arborea, *Linn.* (Verbenaceæ), the *Kumber* or *Kunbher* of Ulwar. Is used for making *saringis* (musical instruments) cups, toys, furniture, pannels of carriage doors and all kinds of ornamental work. It takes paint, polish and lac readily.

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Holarrhena antidysenterica, *Wall.* (Apocynaceæ), the *Kura* of Saharanpur ; the *Veppalai* supposed to be used in Vellore, North Arcot, for lac turnery.

Jasminum grandiflorum, *Linn.* (Oleaceæ), the *Chameli*-wood of Jaipur is good for toys, but too soft for charpoy legs.

Lagerstrœmia Flos-reginæ, *Retz.* (Lythraceæ), the *Ajur* of Assam.

Mangifera indica, *Linn.* (Anacardiaceæ), the mango is largely used in Agra ; occasionally in Hoshiarpur, is only rarely used in Jaipur.

Melia Azedarach, *Linn.* (Meliaceæ), the *Drek* of Hoshiarpur.

Mesua ferrea, *Linn.* (Guttiferæ), the *Nohar* of Assam.

Millingtonia hortensis, *Linn. F.* (Bignoniaceæ), the *Akas nim* of Saharanpur.

Mimusops indica, *Kurz* (Sapotaceæ), the *Khirini* of Indergarh in Kohat State, Rajputana.

M. Kauki, *Linn.*, is said to be the *Khirini* of Shahpura in Rajputana, where it is said to be imported from Jaipur and Gwalior.

Morus indica, *Linn.* (Urticaceæ), the *Shahtut* is in Jaipur used for making *Dunkas* and snuff boxes.

Olea cuspidata, *Wall.* (Oleaceæ), the *Kan* of Shahpur.

Pinus longifolia, *Roxb.* (Coniferæ), the *Chil* of Hoshiarpur.

Populus euphratica, *Oliv.* (Salicaceæ), the *Bhan* of Shahpur ; this is the *Bahan* of Haidrabad, Sind, where it is extensively used and much appreciated for turnery owing to its taking colour easily ; it is a common tree in Sind especially on river banks.

Psidium Guyava, *Linn.* (Myrtaceæ), the Guava is according to a letter received from Mr. E. Thurston, used in Vellore, in North Arcot for lac-turnery.

Stephegyne parviflora, *Korth.* (Rubiaceæ), the *Kain* of Saharanpur.

Sterculia urens, *Roxb.* (Sterculiaceæ), the *Kadhu* of Ulwar. **Sitars** (*Guitars*) and toys are made of it.

Tamarix orientalis, *Forsk.* (Tamaricaceæ), the *Farash* of Agra, the *Ekean* of Shahpur, Pharwan of Ferozpur ; the *Lye* of Haidrabad, Sind, is used for walking sticks, rulers and turnery.

Tecoma undulata, *G. Don* (Bignoniaceæ), the *Rohira* of Marwar or *Roira* of Jaipur, used for charpoy legs, tobacco boxes, etc. In Ulwar this is the *Rohera* and it is said to be useful for toys, agricultural implements and furniture ; it takes a beautiful polish.

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Tectona grandis, *Linn. f.* (Verbenaceæ), the Teak wood or *Sagwan* of Marwar (rarely used), but largely in Khandesh District of Bombay.

Ulmus integrifolia, *Roxb.* (Urticaceæ), the *Kanaj* of Marwar; the *Chhilal* of Jaipur (largely used for the *chalpat*, rattle, the *phirkness*, top, and the *chakis* or humming tops).

Wrightia tinctoria, *R. Br.* (Apocynaceæ), the *Dudhi* of Saharanpur; the *Khirini* or *Khirni* of Marwar, of Indergarh, of Tonk, of Udaipur, of Jaipur; *Kherna Sirohi*, W. Rajputana; *Anni* or *Dudi* of Dholpur.

408. **Mr. T. H. Storey** of Udaipur, Rajputana, who furnished a botanical specimen, and says "this tree abounds in milky juice. Its wood is used in preference to any other owing to its being easy to work and takes lac colours better than any other wood." There is thus no doubt whatever that the *Khirni* of Udaipur is **Wrightia tomentosa**.—*Letter No. 326 E., dated 4th December 1896.* In Ulwar this wood is spoken of as *Khirna*, it is used for toys and scabbards.

Zizyphus Jujuba, *Lamk.* (Rhamnaceæ), the *Bar* of Hoshiarpur, Shahpur; *Bordi*, *Sirdhi* of W. Rajputana.

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FOOD GRAINS AND FODDERS.

(INDIA.)

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Other PAPERS that may be consulted:

The Agricultural Ledger, 1892, No. 1; 1893, No. 15; 1894, No. 2; 1896, No. 40; 1898, No. 19; 1899, Nos. 1, 4; 1900, No. 1.

INDIAN FOOD GRAINS AND FODDERS: THEIR CHEMICAL COMPOSITION

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PLAN OF THIS PAPER.

In the following pages will be found information regarding the composition of some of the Indian food grains and fodders. It is anticipated that a second edition of this work can be issued in about twelve months, when much will be added to it. It will, however, prove of assistance to the author, if those interested in the subject will in the meantime kindly communicate to him any suggestions which occur to them as being useful. With regard to the arrangement, among other things, it may prove more convenient for some readers if the following were adopted in future:—Part I, Grains, (*a*) cereals and millets, (*b*) pulses, (*c*) oil-seeds. Part II, Fodders, (*a*) cereals, millets and grasses, (*b*) pulse crops, (*c*) oil-seed crops. Part III, Oil-cakes. Part IV, Roots and tubers; the individual groups being arranged alphabetically according to their botanical names.

In this edition the food grains and fodders are arranged under their botanical names, in simple alphabetical order, and the chief local names are added.

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PLAN OF THIS PAPER.

An accurate knowledge of the chemical composition of the Food crops of any country is of importance. In the case of India, the information of this nature, which has been available in the past, is very limited. On the other hand the number of crops of different natural orders is larger than in most countries, and that of varieties of the same crop is correspondingly greater. Consequently, the chemical analysis of only a few specimens of each of these varieties would entail a work of very considerable magnitude. Such, for the present, is not being attempted. If, however, the chief characteristics of the composition of the principal crops is determined, a want which is experienced by those who are studying Indian agriculture will be in part supplied.

The source from which the samples have been obtained is stated for each sample. Some few of the analyses were made during the time Mr. S. H. Collins held charge of the laboratory and their authorship is hereby acknowledged. These analyses are marked with a † .

METHOD OF ANALYSIS.

Regarding the methods of analysis a few words may be usefully added. These are not quite uniformly the same in all countries, and consequently the published analyses of food stuffs are not always comparable in details. The following notes are therefore made.

Moisture.—This has been determined in all cases by drying in an air-oven at about 100° c.

The ***oil*** has been extracted from the *air-dry* sample with rectified, but not desiccated, ether.

The ether extract has usually only been determined in the grain, in which case it may be assumed to be almost entirely oil.

In the green fodders and straw or *bhusa* of crops, the matter soluble in ether includes largely other substances than oil, such as wax, chlorophyl or even Alkaloids in some cases. It has, therefore, been generally omitted from the analysis of these materials.

Albuminoids.—In some of the older samples, the proportion of Albuminoid nitrogen was not separately determined, and for these the amount of total nitrogen has been multiplied by the usual factor 6·25 and the product entered as Albuminoids. All such have been marked with an * . In all the samples marked 99 or co, the Albuminoid Nitrogen was separated by Retthousen's method (precipitation with Capric hydrate). In a few other cases Church's

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METHOD OF ANALYSIS.

method was employed. As will be seen, nearly the whole of the nitrogen in grain exists as Albuminoids; it is only in fodders that any very marked divergence exists between the amount of total and Albuminoid Nitrogen.

Soluble Carbohydrates.—This term is applied in England to those component parts of food stuffs which are not separately determined.

In cereals and pulses it includes principally starch, but in other cases, such as some of the oil seeds, there is but little starch; its place being taken by such substances as pectin or mucilage.

Woody Fibre.—This includes principally cellulose, but any lignin which is present in the grain or fodder is included.

Soluble Mineral Matter.—Most of the samples were very clean and free from earthy admixture. But since some extraneous earth was usually present and difficult to remove thoroughly, the soluble part of the "ash" or mineral matter has been stated separately, and the other insoluble portion, which consists principally of the silica natural to the grain or fodder has been entered in the next column. Usually grain contains very little silica, and if any earthy matter was adhering to the sample, its presence is at once indicated. But the straws and grasses contain high proportions of silica as an integral part of their normal composition. Earth or dust also usually adheres to these fodders, which is only partially removed on the threshing floor. Information regarding the composition of the ash will be supplied later.

FOOD GRAINS, ETC. Indian Food Grains and Fodders:

Botanical Name—**Andropogon halepensis**—(*Sorghum saccharatum.*)
English Name—American Sorghum.
Vernacular Name—*Shalu.*

GREEN FODDER.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
18—96	Reaped green	Nagpore	70·96	...	·81	12·14	12·57	1·23	2·29	·18	·13
20—96	,, ripe	,,	57·15	...	1·22	19·17	18·13	1·29	3·04	·26	·19

Botanical Name—**Andropogon Sorghum**—(*Sorghum vulgare.*)
English Name—The Indian or Great Millet.
Vernacular Names—*Juar, Cholum.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
63—98	White fine	Surat	12·04	3·06	7·10	74·45	1·39	1·64	·32	1·21	1·13
64—98	,, 2nd class	...	11·55	3·50	6·00	76·70	·96	1·24	·05	1·05	·96
65—98	Red cheap-grain	...	12·08	3·22	9·92	71·47	1·17	1·87	·27	1·67	1·58
273—99	"Khena"	Poona	9·98	3·61	11·87	71·54	1·12	1·83	·05	1·96	1·81
278—99	"Nilwa"	,,	10·43	4·45	11·19	70·99	1·18	1·73	·05	1·91	1·79
279—99	"Dudh Mogra"	,,	10·21	4·13	10·19	71·90	1·22	2·11	·24	1·74	1·63
280—99	"Mal dandi"	,,	8·76	3·47	9·57	74·20	1·75	1·92	·38	1·65	1·53
281—99	"Sundia"	,,	9·90	4·59	12·44	70·05	·79	1·83	·40	2·11	1·99
23—96	...	Nagpore	9·96	7·66	7·69	70·15	2·24	1·67	·63	1·26	1·23

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Botanical Name—**Sorghum Andropogon**—(*Sorghum vulgare.*)

English Name—The Indian or Great Millet.

Vernacular Names—*Juar, Cholum.*

FODDER.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
				Sun-dried Samples.							
356—95	......	Aligarh	8·35	...	4·19	47·85	33·59	3·28	2·74	·70	·67
24—96	Dead ripe	Nagpore	10·79	...	2·24	51·57	25·42	3·04	6·94	·49	·36
174—98†	Sundia not quite ripe	Poona	8·04	2·19	3·83	47·98	27·90	2·91	7·15	·64	·61
175—98†	Kawbi not quite ripe	,,	7·35	2·11	2·29	46·27	31·38	3·45	7·15	·41	·37
				Fresh-cut Samples.							
19—96	Cut green	Nagpore	69·76	...	·55	14·74	11·90	1·17	1·88	·113	·088
21—96	Cut ripe	,,	67·02	...	·64	16·42	12·78	1·52	1·62	·173	·103
317—96	Cut in October	Cawnpore	56·10	...	3·10	20·65	15·32	2·29	2·54	·56	·50
318—96	2nd cutting in March	,,	63·77	...	1·54	18·50	10·35	1·77	4·07	·42	·25
319—96	Cut in March	,,	48·78	...	2·01	25·31	15·92	2·10	5·88	·43	·32

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Botanical Name—**Arachis hypogæa.**
English Names—Ground Nut, Earth Nut, Pea Nut.
Vernacular Names—Múngphali, vilyáetí-múng.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
58—93	(Kernels only) . .	......	4·70	49·25	29·09*	13·21	1·65	2·15	·05	4·65	...

Botanical Name—**Arachis hypogæa.**
English Names—Ground Nut, Earth Nut, Pea Nut.
Vernacular Names—Múngphali, viláyetí-múng.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
57—93	(Shells only) . . .	......	7·35	2·80	7·57*	13·73	55·35	9·45	3·75	1·21	...

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Botanical Name—**Avena sativa.**
English Name—Oats.
Vernacular Name—*Jai.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
†6—98	......	Dehra Dun . .	10'17	5'27	6'39	61'57	11'29	1'89	3'42	1'18	1'02
173—93	Cape Oats . . .	......	10'80	5'93	8'77*	57'95	12'50	1'25	2'80	1'40	...

Botanical Name—**Avena sativa.**
English Name—Oats.
Vernacular Name—*Jai.*

STRAW.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
203—94	......	Cawnpore . .	9'53	...	1'37	43'48	36'09	3'72	5'81	...	'22

FOOD GRAINS, ETC. **Indian Food Grains and Fodders :**

Botanical Name—**Brassica campestris.**
English Name—
Vernacular Name—
GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	eral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
186—93	"Yellow Sarson" . .	Cawnpore . .	6·15	41·37	23·61*	22·25	2·97	3·40	·25	3·76	...
187—93	"Black Sarson" . .	" . .	7·15	33·87	25·89*	22·04	6·40	4·30	·35	4·14	...
193—93	"Rai"	" . .	7·50	28·90	16·29*	31·87	5·43	6·16	3·85	2·61	...

Botanical Name—**Cajanus indicus.**
English Names—Pigeon Pea, Congo Pea.
Vernacular Names—*Arhar, Tor, Tur.*
GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
79—99	Red	Poona . . .	8·08	1·32	19·38	61·39	5·94	3·80	·09	3·35	3·10
90—99	White	" . . .	7·92	1·23	18·69	62·64	5·99	3·44	·09	3·44	2·99
271—99	"	" . . .	8·64	1·91	19·19	60·58	5·24	3·86	·58	3·41	3·07

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Botanical Name—**Cajanus indicus.**

English Names—Pigeon Pea, Congo Pea.

Vernacular Names—Arhar, Tor, Tur.

STRAW OR "BHUSA" (PRINCIPALLY LEAVES AND PODS).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Sica.	Total Nitrogen.	Albuminoid Nitrogen.
54—99	"White"	Poona	6·77	6·93	13·25	51·38	18·10	6·44	3·13	2·45	2·12
55—99	"Red"	"	6·22	7·94	14·94	46·51	14·35	6·12	3·92	2·60	2·39
266—99	......	"	8·89	2·97	7·38	49·94	21·74	6·46	2·62	1·42	1·18
205—94	......	Cawnpore	5·58	...	7·39	45·74	25·69	6·23	8·37	...	1·18

Botanical Name—**Carthamus tinctorius.**

English Names—Safflower, American Saffron.

Vernacular Names—Kusumba, Kusum, Kurdi, Kar.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
95—95	......	Poona	7·49	31·84	13·31*	18·66	26·31	2·39	...	2·13	...
15—98†	......	"	5·11	27·08	8·41	22·58	32·69	1·83	·30	2·17	1·34
92—99	......	"	6·04	18·28	20·44	27·51	23·60	3·78	·35	3·77	3·27

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Botanical Name—**Carthamus tinctorius.**

English Names—Safflower, American Saffron.

Vernacular Names—*Kusum, Kusumba, Kurdi, Kar.*

OIL CAKE.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
16—98†	......	Poona . . .	12·00	3·78	16·91	41·48	19·40	4·36	2·07	4·92	2·70

Botanical Name—**Cicer Arietinum.**

English Names—Common Gram, Chick Pea.

Vernacular Name—*Chana.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
24—98†	......	Dehra Dun . .	9·88	3·95	17·05	60·03	6·51	2·40	·18	2·72	2·98
82—99	......	Poona . . .	7·99	3·89	21·37	54·97	8·32	3·16	·30	3·73	3·42
272—99	......	,, . . .	8·60	5·31	15·50	60·13	7·21	3·06	·19	2·71	2·48
182—93	......	Cawnpore . .	11·35	4·83	18·57*	56·33	6·17	2·75	...	2·96	...

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Botanical Name—**Cicer Arietinum.**

English Names—Common gram, Chick Pea.

Vernacular Name—Chana.

STRAW OR "BHUSA" (STEMS, LEAVES AND PODS.)

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
57—99	......	Poona . . .	6·56	2·69	3·06	44·55	28·93	9·29	4·92	·68	·49
264—99	......	,, . . .	8·21	2·64	2·94	49·70	21·87	11·81	2·83	·67	·47
204—94	......	Cawnpore . .	10·11	...	4·46	38·84	27·63	9·66	9·30	...	·71

Botanical Name—**Cocos Nucifera.**

English Name—Cocoa Nut.

Vernacular Names—Nárel, dab.

THE CAKE.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
23—98	......	Poona . . .	7·72	16·53	13·62	44·57	12·45	4·65	·46	3·31	2·17

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FOOD GRAINS, ETC. **Indian Food Grains and Fodders :**

Botanical Name—**Cyamopsis psoralioides.**

English Name—

Vernacular Names—*Guar, Khurti, Khulti, Guwar.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
108—99	......	Poona . . .	8·99	2·99	28·31	48·42	7·68	3·32	·29	4·93	4·53

Botanical Name—**Dalichos biflorus. D. uniflorus.**

English Name—Horse gram.

Vernacular Name—*Kulthi, kalathi.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
101—99	......	Poona . . .	7·45	·89	20·06	60·62	4·57	4·34	2·07	3·74	3·21

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Botanical Name—**Dolichos Lablab.**

English Name—

Vernacular Names—Sem, Lobia, Val, Wal.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
106—99	......	Poona . . .	7·11	·93	23·31	56·98	6·94	3·99	·74	4·06	3·73
267—99	"Mettia" . . .	" . . .	9·55	2·03	23·44	53·26	7·42	4·20	·10	4·07	3·75
268—99	"Kadawa" . . .	" . . .	9·08	1·11	20·75	58·38	6·78	3·85	·05	3·46	3·32
269—99	"Damania" . . .	" . . .	9·70	1·14	19·56	61·94	4·69	2·92	·05	3·24	3·13
270—99	"Watania" . . .	" . . .	9·19	1·17	23·31	55·35	6·12	3·69	1·17	3·98	3·73

Botanical Name—**Dolichos Lablab.**

English Name—

Vernacular Names—Sem, Lobia, Val, Wal.

"BHUSA" (STEM, LEAVES AND PODS).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
263—99	......	Poona . . .	9·92	3·72	13·37	43·04	16·17	11·27	2·51	2·56	2·14

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Botanical Name—Eleusine Coracana.

English Name—Coracan.

Vernacular Names—*Marua, Kodon, Nagli, Bavto Nagli, Ragi.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
87—99	......	Poona.	9·38	1·38	5·37	78·46	2·47	2·47	·47	·95	·86

Botanical Name—Gossypium (herbaceum).

English Name—Cotton seed.

Vernacular Names—*Ruï, kupás,*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
20—98†	......	Poona . . .	8·52	18·33	11·74	38·78	17·53	3·92	1·22	2·57	1·87
171—98†	......	" . . .	6·93	14·57	11·34	35·96	25·05	4·47	1·68	2·49	1·81
172—98†	......	Surat . . .	6·83	16·51	12·54	32·54	27·11	4·23	·24	2·86	2·00
301—99	Egyptian seed . .	...	6·75	28·40	22·63	21·06	16·71	4·19	·26	3·78	3·63

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GRASS AND HAY.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
17—95	P med grass	Cawnpore	10·07	...	4·45	50·80	29·76	2·37	2·55	·86	·71
209—95	Cut dry	Nagpore	9·81	...	1·54	39·39	34·58	2·67	12·01	·26	·25
210—95	„ green	„	9·23	...	2·46	44·16	31·75	1·74	10·66	·41	·39
295—95	......	Kaira District, Gujarat	8·72	...	2·45	45·87	34·48	1·10	7·38	·452	·392
122—97	......	Aligarh	6·87	...	5·60	48·99	30·08	3·15	5·31	1·05	·89
396—94	......	Gursikran, Aligarh	13·83	...	3·56	48·16	25·42	3·64	5·39	...	·57
391—94	......	Saharanpore	47·43	...	2·66	22·00	22·23	2·36	3·32	...	·42
144—93	......	Commissariat Department	11·07	...	2·69	45·40	32·07	2·05	6·72	...	·47
199—98	......	Aligarh	4·75	...	3·06	50·87	32·04	2·39	6·89	...	·49
368—00	Navapur	Bombay	12·33	...	2·12	51·21	27·16	2·83	4·28	·37	·34
369—00	Thana	„	12·21	...	1·50	39·13	35·54	4·30	7·32	·25	·24
370—00	Saugar	Central Provinces	12·59	...	2·07	49·89	28·11	2·55	6·79	·35	·33
371—00	Jubbulpore	„ „	11·78	...	2·31	43·51	33 66	2·38	6·36	·37	·37
372—00	Budui	„ „	11·36	...	1·31	44·42	35·24	1·99	5·68	·21	·21
373—00	......	......	11·77	...	1·50	47·59	27·69	2·50	8·97	·31	·24
374—00	Kulphar	......	11·89	...	1·37	49·94	26·86	2·09	7·85	·22	·22
377—00	Bhopal	......	10·78	...	·94	43·92	34·98	1 14	8·24	·15	·15
378—00	Hiranin	......	11·58	...	1·31	46·33	31·80	2·14	6·84	·22	·21
379—00	Sohagpur	......	110·9	...	1·37	48·24	32·98	1·54	4·96	·29	·22

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Botanical Name—**Guizotia abyssynica.**
English Name—Niger seed.
Verancular Names—*Kala til, Ramatila.*

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
93—99	......	Poona	4·88	38·03	19·31	17·47	9·20	6·69	4·42	3·19	3·09
173—95	......	Lucknow	8·43	38·20	19·25*	11·49	15·19	4·36	3·08	3·08	...
272—94	......	Poona	6·15	41·14	20·09*	15·08	12·10	4·37	1·09	3·24	...

Botanical Name—**Hordeum Vulgare.**
English Name—Barley.
Vernacular Names—*Jao, Jaw, Jav, Satu.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
4—98†	......	Cawnpore	11·85	1·84	8·04*	72·65	3·24	1·99	·39	1·29	...
168—93	"White huskless"	Poona	12·18	1·83	7·92*	74·12	2·10	1·00	·85	1·26	...
164—93	"Country white"	"	13·74	1·80	8·29*	70·32	3·49	1·76	·60	1·33	...
165—93	" " black"	"	12·55	1·93	7·73*	69·71	5·63	·85	1·60	1·24	...
166—93	"Chocolate"	"	12·79	1·97	8·24*	73·23	1·73	1·89	·15	1·32	...

F. 669-74.

Botanical Name—**Hordeum Vulgare.**
English Name—Barley.
Vernacular Names—Jao, Jaw, Jav, Satu.

"BHUSA" (STRAW AND CHAFF).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
202—93	......	Cawnpore . .	7·93	...	4·00	41·45	34·82	5·55	6·25	...	·64

Botanical Name—**Lathyrus sativus.**
English Name—Wood Pea.
Vernacular Names—Khesari, Karas, Lakh, Lang.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
107—99	......	Poona . . .	7·89	·79	24·69	57·98	4·28	3·18	1·19	4·21	3·95

F. 669-74.

Botanical Name—**Lathyrus sativus.**

English Name—Wood Pea.

Vernacular Names—*Khesari, Karas, Lakh, Lang.*

BHUSA (STEMS, LEAVES AND PODS).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
56—99	......	Poona . . .	6·10	5·00	9·75	45·39	19·36	9·49	4·91	1·96	1·56
265—99	......	„ . . .	11·08	2·93	9·25	43·03	20·57	10·46	2·68	1·66	1·32

Botanical Name—**Lens esculenta.**

English Name—Lentil.

Vernacular Name—*Masur.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
103—99	......	Poona . . .	8·03	1·06	23·00	61·14	2·42	3·54	·81	3·94	3·68

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Botanical Name—**Linum usitatassimum.**

English Name—Linseed.

Vernacular Names—Alsi, Alshi, Javas.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
94—99	Brown	Poona	4·97	37·47	20·92	26·24	5·60	3·96	·84	3·71	3·35

Botanical Name—**Medicago sativa.**

English Name—Lucerne.

Vernacular Names—Wilayti-gawuth, alfalfa.

GREEN FODDER.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
51—99	......	Poona . . .	77·75	·76	3·00	11·89	3·74	2·75	·11	·71	·48
53—99	......	,, . . .	78·32	·75	3·81	11·21	3·35	2·44	·12	·81	·61

Botanical Name—Panicum Frumentaceum.

English Name—Millet.

Vernacular Names—*Sawan, Sawank, Sawa, Bavto, Bunti.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
80—99	......	Poona . . .	7·72	4·39	7·06	67·56	7·44	1·70	4·13	1·18	1·13

Botanical Name—Panicum jumentorum.

English Name—Guinea grass.

Vernacular Name—*Gini Ghas.*

GREEN FODDER.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
50—99	......	Poona . . .	63·38	·84	1·88	19·36	8·79	2·60	3·15	·41	·30
52—99	......	„ . . .	71·55	1·05	2·62	13·71	5·73	1·87	3·47	·53	·42

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Botanical Name—**Panicum miliaceum.**

English Name—Common Millet.

Vernacular Names—China, Salar, Sava, Vari, Varagu.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
97—99	......	Poona . . .	8·57	·09	9.38	64·21	6·30	2·50	3·95	1·52	1·50

Botanical Name—**Panicum miliare.**

English Name—Little Millet.

Vernacular Names—Kutki, Avarai.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
88—99	......	Poona . . .	7·95	4·11	6·81	67·26	7·63	2·16	4·08	1·18	1·09

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Botanical Name—**Paspalum scrobiculatum.**
English Name—
Vernacular Names—*Kodo, Kodon, Kodra.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
85—99	......	Poona . . .	8·01	3·36	5·81	70·06	8·47	1·34	2·95	1·00	·93

Botanical Name—**Pennisetum typhoideum.**
English Names—Bulrush Millet, Spiked Millet.
Vernacular Names—*Bajra, Kumbu.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
81—99	......	Poona . . .	8·05	5·36	9·88	74·26	·60	1·60	·25	1·72	1·58
84—99	"Bhownaggari" . .	" . . .	8·60	5·37	9·37	73·94	·86	1·68	·18	1·58	1·41
91—99	"Awned" . . .	" . . .	8·09	5·50	10·00	72·99	·60	2·12	·68	1·70	1·60
95—99	"Nadiad" . . .	" . . .	8·87	5·08	8·62	74·75	·90	1·59	·19	1·47	1·38
96—99	"Poona" . . .	" . . .	8·96	5·75	8·12	74·11	·93	1·74	·39	1·34	1·30

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Botanical Name—**Phaseolus aconitifolius.**

English Name—

Vernacular Names—*Moth, Mut.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
105—99	......	Poona . . .	8·59	1·07	22·50	58·85	4·24	3·99	·76	4·01	3·60

Botanical Name—**Phaseolus Mungo.**

English Name—Green gram.

Vernacular Names—*Mung, Mug.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
104—99	......	Poona . . .	9·48	1·83	23·56	56·39	4·42	4·02	·30	4·03	3·77

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Botanical Name—**Phaseolus radiatus.**

English Name—

Vernacular Names—Urd, Urad, Mash.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
136—98†	......	Poona . . .	11·87	·70	16·08	54·35	3·39	2·45	1·16	2·90	2·57
100—99	......	„ . . .	8·14	·99	18·50	59·11	4·33	4·51	4·42	3·24	2·96

Botanical Name—**Pisum sativum.**

English Name—Garden pea.

Vernacular Names—Bara-Mattar, Sen, Vatane, Watana.

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
180—93	White	Cawnpore . .	12·05	1·27	24·12*	54·44	5·41	2·65	...	3·84	...
181—93	Black	„ . .	11·25	1·47	24·67*	52·47	6·67	3·30	·15	3·95	...
99—99	Vatane	Poona . .	7·89	1·40	20·06	62·12	5·69	2·79	·05	3·38	3·21

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Botanical Name —**Pisum sativum.**
English Name—Garden pea.
Vernacular Names—Bara-Mattar, Sen, Vatane, Watana.
"BHUSA" (STEMS, LEAVES AND PODS).

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
58—99	......	Poona	7·27	3·02	11·75	42·43	19·36	9·65	6·52	2·49	1·88
206—94	"Pea Straw"	Cawnpore	9·88	...	9·94	42·83	22·27	9·35	5·73	...	1·59

Botanical Name—**Sesamum indicum.**
English Names—Gingelly, Sesame.
Vernacular Names—Til, Gingili.
GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
86—99	"Red"	Poona	4·18	49·12	20·37	14·16	2·93	6·65	2·59	3·34	3·26
89—99	"Black"	"	4·13	47·60	18·12	18·56	4·14	6·80	·59	3·11	2·90
98—99	"White"	"	4·21	51·96	18·06	14·62	4·49	6·28	·38	2·99	2·89
86—97	"	Nagar	4·87	48·13	22·50*	14·05	4·49	5·59	·37	3·60	...
87—97	"Black"	Nadiad	5·42	46·50	25·81*	9·06	6·51	6·03	·06	4·13	...
88—97	"Red"	Nagar	5·37	46·20	21·03*	15·87	4·18	6·00	1·35	3·37	...

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FOOD GRAINS, ETC. **Indian Food Grains and Fodders:**

Botanical Name—**Setaria italica.**

English Name—Italian Millet.

Vernacular Names—*Rala, Kangu, Kangni.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
78—99	......	Poona . .	7·95	4·54	10·37	69·19	5·22	1·44	1·49	1·68	1·66

SILAGE.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
208—95	......	Nagpore . .	12·08	...	2·53	40·52	33·95	1·58	9·34	·47	·41

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Botanical Name—**Triticum vulgare** (*T. sativum*).
English Name—Wheat.
Vernacular Name—*Gehun.*

GRAIN.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
1—98	......	Cawnpore	12·72	1·84	9·10	72·88	1·68	1·72	·12	1·46	...
151—93	Country bearded	,,	13·35	1·73	8·47	73·08	1·57	1·75	·05	1·36	...
152—93	Country beardless	,,	13·19	1·60	9·75	72·03	1·93	1·40	·10	1·56	...
153—93	Buxa	,,	12·95	2·13	8·91	72·70	1·56	1·70	·05	1·43	...
154—93	Sindhi	,,	12·21	1·66	9·92	72·68	1·73	1·80	...	1·59	...

Botanical Name—**Triticum vulgare.** (*T. sativum*).
English Name—Wheat.
Vernacular Name—*Gehun* (*Choker*).

BRANS.

No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble Mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
2—98†	......	Dehra Dun	12·93	4·94	7·56	65·78	5·47	3·14	·18	1·45	1·21
129—98†	......	Poona	11·88	4·19	10·90*	58·66	9·37	4·56	·44	1·74	...
1899	......	,,	9·10	4·40	14·09*	61·03	6·29	4·82	·27	2·25	...

FOOD GRAINS, ETC. **Indian Food Grains and Fodders: their Chemical Composition.**

Name of product examined.	No.	Local description.	Source.	Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody Fibre.	Soluble mineral matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
Andropogon halepensis.												
Syn. Sorghum saccharatum.												
American sorghum.												
Vern.—*Shalu*.												
Green fodder . .	18—96	Reaped green .	Nagpur .	70·96	...	0·81	12·14	12·57	1·23	2·29	0·18	0·13
	20—96	„ ripe .	„ .	57·15	...	1·22	19·17	18·13	1·29	3·04	0·26	0·19
Andropogon Sorghum.												
Syn. Sorghum vulgare.												
Indian or Great Millet.												
Vern.—*Juar, cholum.*												
Grain . . .	63—98	White fine .	Surat .	12·04	3·06	7·10	74·45	1·39	1·64	0·32	1·21	1·13
	64—98	„ 2nd class	...	11·55	3·50	6·00	76·70	0·96	1·24	0·05	1·05	0·96
etc., etc.												

G. I. G. P. O.—No. 1193 R. & A.—5-8-1901.—2,230.—Jos. C.

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(Medical and Chemical Series, No. 15.)
(Medicinal Products.)

THE AGRICULTURAL LEDGER.

1901—No. 11.

PTEROCARPUS MARSUPIUM.

(KINO TREE.)

[*Dictionary of Economic Products, Vol. I., Pt. I.,* P. 1370-80.]

MALABAR KINO:

Its Collection, Composition and Trade;

With a revision of the Dictionary Article, by MR. D. HOOPER, F.C.S., F.L.S.

INTRODUCTORY.

The revision of the article on **Pterocarpus Marsupium** in *The Dictionary of Economic Products* has been rendered necessary on account of the great interest attached to the recent fluctuation in the price of medicinal kino and its causes. During the course of an extensive correspondence between the Reporter on Economic Products and members of the Forest service, important additional information has been obtained with regard to the distribution of the tree and the collection and preparation of its juice for the European market. Authentic specimens of the kino from the different localities have been forwarded to the Reporter and deposited in the Economic Court of the Indian Museum, and an opportunity has been taken to subject the samples to comparative tests in the chemical laboratory, especially in respect to their tannin value.

The genuine Malabar kino is an important indigenous drug in India which has been recognised many years in the the British and other Pharmacopœias. An unlimited supply is now obtainable through the Forest Department and at a price that will preclude all competition of other articles of a similar nature.

INTRODUCTORY.

Pterocarpus Marsupium, *Roxb., Fl. Br. Ind., II., 239; Ind. Kew., IV., 652.*

THE INDIAN KINO TREE.

Syn.—P. BILOBUS, *Roxb.*

Vern.—*Bija, bijasar, bijasal, piasal, pit-shola, banda,* HIND.; *Pit-shal, pit-sal,* BENG.; *Byasa, piasal, bijasa,* URIYA; *Hitun, hid, hed, hilum, paisar,* KOL.; *Murga, banda,* SANTAL; *Peddei, bijo,* GOND; *Radatbera,* BHIL; *Bijasal, biah, bijasah, bijaira, dhorbenla,* C.P.; *Bibla, bíbla, huni, asana,* MAR.; *Bibla, bia,* GUZ.; *Bibla, bewba, bia,* DEC.; *Vengai, yeanga, vengai-maram,* TAM.; *Peddagi yeanga, yeggi, yegisa, pedega, pedei, vegisa, egisa, vegi, pedyegi,* TEL.; *Benga, honne, bibla, honnemaradabanke,* KAN.; *Hunne, karinthagara, venna, venna-maram,* MALAY; *Gummalu, ganmalu,* SING.; *Katimukki,* ARAB.; THE GUM-*Hira-dokhi, kholar-manda, rang-barat,* HIND.; *Nat-ka-dam-mul-akhvain,* DEC.; *Kandamiruga-mirattam,* TAM.; *Gandam-rugam-netturu,* TEL.; *Vennapasha,* MALAY.; *Dam-mul-akhvaine-hindi,* ARAB.; *Khune-siyavushane-hindi,* PERS.

References.—*Roxb., Fl., Ind., Ed., C. B. C., 536; Voigt, Hort. Sub. Cal., 242, Brandis, Fl., 152; Beddome, Fl. Sylv., t. 21; Gamble, Man. Timb., 132; Dalz. and Gibs., Bomb. Fl., 76; Rev. A. Campbell, Rept. Econ. Pl. Chutia Nagpur, Nos. 9465, 9466; Sir W. Elliot, Fl. Andhr., 49, 190; Pharm. Ind., 70; Flück. and Hanb., Pharmacog., 194; Ainslie, Mat. Ind., II, 264; O'Shaughnessy, Beng. Dispens., 299; Medical Topog. Ajm., 131; Moodeen Sheriff, Supp. Pharm. Ind., 208; Murray, Pl. and Drugs, Sind, 128; Dymock, Mat. Med., W. Ind., 2nd Ed., 239, 888; Dymock, Warden and Hooper, Pharmacog. Ind. I., 464; Trans., Med. and Phys. Soc. Bomb. (New Series), No. 12, 173; Birdwood, Bomb. Prod., 30, 266, 311, 329; Drury, U. Pl. Ind., 357; Useful Pl. Bomb. (XXV., Bomb. Gaz.), 62, 251, 394; Econ. Prod., N.-W. Prov., Pt. I. (Gums and Resins), 3; Gums and Resinous Prod. (P. W. Dept. Rept.), 2, 3, 5, 7, 9, 25, 32, 65, 67; Cooke, Gums and Resins, 35; Wardle, Dye Rep., 26; Christy, New Com. Pl., V., 39, 40, 44; Man. Madras, Adm., I., 313; II., 64; Nicholson, Man. Coimbatore, 401; Boswell, Man. Nellore, 101; Moore, Man. Trichinopoly, 79; Gribble, Man. Cuddapah, 199, 262; Settlement Reports:—Central Provinces, Nemar, 305; Raipur, 75; Chanda, App. VI.; Godavery, 37; Seonee, 10; Chindwara, 110, 111; Bhandara, 18; Gazetteers:—Bombay, III., 199; VII., 32, 35, 39; XIII., 23; XV., 33; XVI., 19; XVII., 24; Central Provinces, 58, 503; Mysore and Coorg, I., 48, 71;*

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III., 21; Journals;—Agri-Horti. Soc., Ind. (Old Series) IV., Pro., 21; V., 110, 113; VIII., Sel., 140; IX., 294, Sel. 51, Pro., 149; XIV., Sel., 166; (New Series), IV., Pro., (1873), 38; VII., 136; Ind. Forester, I., 274; II., 18, 19; III., 23, 189, 201; IV., 292, 322, 366, 411; VI., 104, 304; VIII., 105, 118, 125, 126, 378, 411, 414, 415, 416, 417, 438, 439, 440; IX., 294, 356, 427; X., 33, 222, 325, 326, 547, 550, 552; XI., 230; XII., 85, 188, 313; XIII., 120; XIV., 151. Pharm. Journal, Vol. 64, 1549, p. 226. Chemist and Druggist, 1898; Feb. 26, p. 355; July 9, p. 57; July 30, p. 207. Indian Forester, October 1900 (Appendix).

Habitat.

Habitat.—A large deciduous tree of Southern and Central India and Ceylon, extending northwards as far as the Banda District of the North-Western Provinces. Most abundant in the North Malabar district of the Madras Presidency, where the juice is manufactured into the drug. The tree occurs in fair abundance in the Coimbatore, Nilgiri and Tinnevelly districts of the Madras Presidency, also in Berar and the Central Provinces. In all these localities kino might be obtained if a necessary demand arose. In the Northern and Southern Forest Circles of Bombay no kino industry exists, but the *Bibla* or *Bia* is a valuable timber tree especially in the Thana Division, and it would not pay Government to sacrifice a fixed revenue from timber for a product of much less value as the gum from the tree. In Hyderabad (Nizam's Dominions) **Pterocarpus Marsupium** is at present one of the most valuable reserved trees under the Forest Department.

Abundant in Madras.

Major D. Prain, I.M.S., in an appendix to the "Indian Forester," October, 1900, has arranged this species under two varieties, each of which shows two distinct geographical forms.

Var. α.—Form 1, *biloba;* occurs in Ceylon, and in Coimbatore, South India.

Form 2, *vera;* occurs in the Nilgiris, North Arcot, Nellore, Carnatic, Cuddapah, Bellary, Kurnool, Kistna, Mysore, Vizagapatam, Godaveri, Ganjam, Orissa, Sonthal Pergunnahs, Chota Nagpur, and Central Provinces.

Var. β.—Form 3, *acuta;* occurs in Rajmahal Hills, North-Western Provinces and Oudh, Kumaon, North Malabar, and Coorg.

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Form 4, *acuminata ;* occurs in Behar, Central Provinces, Berar, Central India, Deccan, Rajputana, Concan and Kanara.

History.

History.—Dr. Pereira remarks on the history of gum kino that "in 1757 Dr Fothergill described an astringent gum which he supposed (though on very loose evidence) to have been brought from the river Gambier, and hence he termed it **Gummi rubrum astringens gambiense.**" In 1774 it was introduced into the Edinburgh Pharmacopœia as Gummi Kino, and in 1787 into the London Pharmacopœia as Resina Kino. It was described under this designation in the third edition of Lewis's *Exp. Hist. of the Mat. Med.*, by Dr. Aikin in 1784. In 1794 Schenck published an inaugural dissertation on it (Pereira, *Mat. Med.*, ii., 325).

The origin of the word is probably derived from *kano* the Mandigo name for **Pterocarpus erinaceus** which yields a similar gum in Africa. The Persian name for the drug is *Khune*, while in the Central Provinces *Kinta* is one of the names for **Butea** kino. The word has by some been referred to *Carnis* in allusion to the "flesh"-coloured appearance of the juice.

Malabar kino does not appear to have been noticed by Hindu or Mohammadan medical writers, and Dr. Ainslie in "Materia Indica" (ed. 1826, p. 185) states that the drug is but slightly known in India.

The drug has often been subject to adulteration, and in 1841 Dr. Pereira detected many impurities in it. The gum of **Butea frondosa** has occasionally been substituted for the official kino, and this exudation, both in its natural state, and as met with in the bazars, is of very inferior quality.

Collection.

Collection.—The manufacture of kino from the juice of the *Vengai* (**Pterocarpus Marsupium**) is conducted in the district of North Malabar. Anjurakandy, a village at the foot of the ghats, is supposed to be the site of the factory where the first supply was prepared for the market early in the past century.

Season for collecting.

The best season for collecting kino is in the dry weather during February and March when the trees are in blossom. The gum is of inferior quality during the rains, and in the process of drying at this season the use of artificial heat would have to be resorted to. The tree "bleeds" pretty freely at all times of the year.

The Karambars or hill tribesmen of the district, whose chief

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COLLECTION OF KINO.

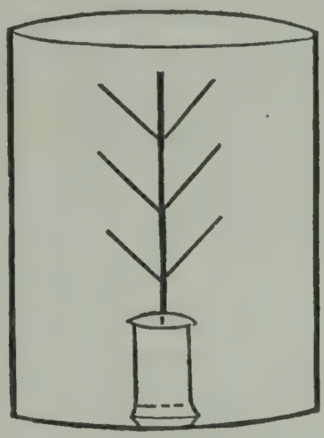
means of livelihood is the collection of minor forest produce, have hitherto employed very wasteful methods in extracting the juice.

The right to tap the trees is now put up to auction together with that of collecting other forest produce such as beeswax and honey. In other cases the tapping is conducted by rangers under the supervision of the district forest officers; the collection is undertaken subject to the condition of its being done properly and without causing undue damage to the trees.

A few years ago, Mr. J. G. F. Marshall, the District Forest Officer, adopted the following method of collecting it.

Method of preparatio

A longitudinal cut is made with an axe or with a knife called *macha katti* through the bark of the trees down to the cambium about $1\frac{1}{2}$ foot long, and side cuts are made to lead into this. A bamboo tube is then fixed at the bottom of the main incision in order to catch the juice thus—



In the course of about twenty-four hours the flow of the gum ceases, and the bamboo is taken down. When several of these bamboo cups are nearly full they are taken to head-quarters and emptied into a large cauldron, and the juice is boiled. During the boiling, the impurities, consisting of pieces of bark, wood and leaves, rise to the surface and are skimmed off. When sufficiently concentrated to the consistence of a thick extract, it is exposed to the sun in thin layers in shallow vessels until it is dry enough to crumble to pieces. The kino is then weighed and packed away in wooden boxes.

Present method of drying.

The present District Forest Officer, North Malabar, has adopted the plan of drying the juice in shallow trays in the shade. The trays

COLLECTION OF KINO.

are arranged on tiers of shelves in a shelter constructed of bamboo, and the dust is excluded by the use of muslin covered doors. Poured into trays in layers of about $\frac{1}{8}''$ thick, the gum takes about 7 or 8 days to dry. The result is a dark ruby kino of exceptional purity.

Collection in Tinnevelly.

The Extra Assistant Conservator of Forests, Tinnevelly, gives further particulars concerning the collection of the gum on the Papanassam Hills. This officer observed that the juice exudes more freely during the night; in the daytime it appeared to trickle out of the stem with difficulty. The young and middle aged trees, if in a healthy condition, yielded more kino than older and larger trees. V-shaped incisions were made in the bark with a sharp knife, the cut on either side being preferably a foot long. The juice exudes from wounds made at any height of the tree, but as a matter of convenience these should be at the lower portion of the stem or within reach of an ordinary coolie. The gum is received in small earthen pots by means of bamboo pipes leading from the lower ends of the incisions. In the early morning the gum is transferred from the pots to a bottle and covered over, otherwise it solidifies. During the second night the juice does not flow so freely from the same wound, so other incisions are made. About two or three ounces of gum are obtained from each wound.

Collection in Kanara.

In the Kanara District of the Bombay Presidency kino is collected in little cups made with leaves, and consequently assumes the form of concavo-convex cakes, 3 to 4 inches in diameter; this form of the drug is always broken up and garbled by the wholesale dealers.

An opinion is prevalent among the Karumbars that if a tree is fully tapped one year no exudation will take place during the second year, but during the third year the same amount of juice as in the first year will be obtained, and so on every second year.

Yield of Juice.

Mr. Marshall found the yield of juice per tree to be roughly $1\frac{1}{2}$ pounds, which is equivalent to three-quarters of a pound of the dried gum ready for medicinal purposes. Mr. E. D. M. Hooper, Acting Conservator of Forests, Madras, reckoned that a large tree tapped to death in the Wynaad yielded from one to three quarts of juice; another tree eight feet in girth and 30 feet in bole yielded half a gallon (3 ℔ 4 oz. dry gum).

The yield of dry kino from the liquid exudation depends upon the consistence at the time of collecting, but may as a rule be calculated at 50 per cent.

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COLLECTION OF KINO.

Kino substitutes.

In addition to **Butea** kino which is sometimes offered as a substitute for true kino, the astringent gum of Bombax known as *Mocharus* is occasionally used. The kino obtained from **Pterocarpus dalbergioides,** the Padouk tree of the Andamans, is very similar in compositon to that of the *Vengai*. Very little is known about the exudations of **Ougeinia dalbergioides** and **Sesbania grandiflora** which are said to resemble the Malabar drug. The red juice of certain wild nutmeg trees (**Myristica gibbosa and M. Kingii**) has recently been studied and found to have a remarkable resemblance to the official kino. (See *Agricultural Ledger* No. 5 of 1900.)

CHEMISTRY OF KINO.

Chemistry.—Kino consists chiefly of kino-tannic acid, a catechol tannin giving a green reaction with ferric salts. A. Bergholz in 1884 found it to yield carbon 59·65 and hydrogen 4·87 per cent. Boiled with dilute sulphuric acid it affords insoluble kino-red or phlobaphene, and fused with potash it yields, as in Gambier and Cutch, protocatechuic acid and phloroglucol. A solution of kino in water is of a reddish colour, which develops a violet hue when a trace of alkali or a fragment of alkaline acetate is added together with a little ferrous sulphate.

Pyrocatechin.

Kino yields to ether a minute percentage of crystalline pyrocatechin, which is soluble in water, and assumes a green colour in contact with ferric chloride, and turns red on the addition of an alkali.

Kinoin.

K. Etti in 1873 extracted kinoïn in colourless crystals by boiling Malabar kino with twice its weight of hydrochloric acid of specific gravity 1·03°. A solution of kinoin reddens in contact with ferric salts.

Tannin.

Notwithstanding the known astringency of the drug, the amount of tannic acid—the active principle—has rarely been estimated. The earliest analysis was made by "citoyen" Vauquelin in 1803, and recorded in a paper entitled "Experiences sur la gomme kino, ainsi vulgairement appellée." (*Ann. Chim.*, 46, 321). East Indian kino was found by Vauquelin to consist of 75 per cent. of tannin and peculiar extractive, 24 per cent. of red gum, and 1 per cent. of insoluble matter. Although we are unable to learn much of the constituents of kino from these results, the small amount of insoluble matter indicates a degree of purity in the commercial article at the beginning of the century equal to that of the best kino now produced.

Vauquelin's analysis.

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PTEROCARPUS Marsupium.

Malabar Kino: Its Collection,

CHEMISTRY OF KINO.

Analysis by Will and Branch.

Some recent experiments performed by Messrs. Will and Branch have tended to show that while Malabar kino is highly soluble and pure the amount of tannic acid only reaches to about half the weight of the drug.

This series of experiments was made with the object of determining any variation in the composition of kino according to the methods used in drying it. The six samples had been prepared in the following manner:—

No. 1. The juice after collection was boiled and the liquid allowed to dry; this process occupying several weeks.

No. 2. The juice was dried in vessels heated with steam, and only occupied four hours.

No. 3. The juice was spread in layers and exposed to the sun, and dried in twelve hours.

No. 4. The juice was spread in layers about ¼-inch thick and dried in the shade; time required, twenty-four hours.

No. 5. Kino made from unboiled juice.

No. 6. Kino made from boiled juice.

The results of the examination are here tabulated—

Percentage	1	2	3	4	5	6
Soluble in water . .	57	77·4	79·6	77·6	77	58
,, ,, rectified spirit .	78	85·0	81·0	84·0	83	77
,, ,, proof spirit .	78·5	84·0	86·5	83·5	85	79·5
Tannin	39·3	49·2	49·8	45·3	55·1	41·1
Ash	1·3	1·1	1·1	1·3	·8	·7

Here it is seen that the kino dried by artificial heat agrees with that dried by the heat of the sun, and that boiling the juice has a somewhat deleterious effect upon the product.

The figures for tannin are very low, probably on account of the employment of a process for its estimation which has now been superseded.

Examination of Indian Museum samples.

Samples of kino have been examined in the chemical laboratory in the Economic Section of the Indian Museum, with a view to determine more particularly the amount of tannin, moisture and ash.

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CHEMISTRY OF KINO.

Examination of Indian Museum samples.

The following ten samples of kino were received from Forest Officers, and, although not all from Malabar, they were obtained from the official botanical source :—

No. 1. From Mudumalai, Nilgiri-Wynaad; a clean sample prepared direct from the juice and sent by Mr. E. D. M. Hooper in November, 1896 (Reg. No. 8403).

No. 2. Specimen collected at Kollegal, North Coimbatore (Reg. No. 10012).

No. 3. Specimen collected in the Papanassam Hills, Tinnevelly District (Reg. No. 10012-1). The two samples were forwarded by Mr. Hooper in September, 1897.

No. 4. Specimen collected near Chokanhálli in the Sigur range, on the northern slopes of the Nilgiri Hills. Owing to the dryness of the ground the trees here do not bleed freely, and the gum was extracted with some difficulty. Sent by Mr. J. W. Cherry, Conservator of Forests, Southern Circle, Madras, in January, 1898 (Reg. No. 10324).

No. 5. A sample of kino collected in Malabar and supplied to the Madras Medical Store Department (Reg. No. 10381).

No. 6. Sample of mixed shade and sun-dried gum prepared in North Malabar. Forwarded at the instance of the Inspector General of Forests in March, 1898 (Reg. No. 10455).

No. 7. Specimen from Mohenli block, Chanda District, Central Provinces, where the growth of the trees is most vigorous. Sent by Mr. Hooper in August, 1897 (Reg. No. 9901).

No. 8. Kino from Chanda District, Central Provinces. Sent by Mr. A. E. Lowrie, Divisional Forest Officer, August, 1898 (Reg. No. 11100).

No. 9. A sample specially prepared by the same officer and sent in September, 1898 (Reg. No. 11379).

No. 10. A sample of kino as now prepared in the shade in North Malabar. Received from Mr. H. Tireman, District Forest Officer, in April 1899 (Reg. No. 11989).

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PTEROCARPUS Marsupium.

Malabar Kino: Its Collection,

CHEMISTRY OF KINO.

Composition.

The following table exhibits the results of the analyses of the various specimens :—

	Water.	Tannin.	Non-tannins.	In-soluble.	Ash.	Tannin in dry sub-stance.
1. Wynaad	15·7	79·0	3·8	...	1·5	93·7
2. Coimbatore . . .	14·6	82·4	1·6	0·4	1·0	96·5
3. Tinnevelly . . .	15·7	79·6	1·1	1·3	2·3	94·4
4. Nilgiris	15·3	79·1	4·1	...	1·5	93·7
5. Malabar	14·7	79·5	4·2	...	1·6	93·2
6. "	14·9	78·4	4·6	1·0	1·1	92·1
7. Central Provinces . .	13·5	76·4	4·0	4·0	2·1	88·3
8. " " . .	12·2	70·4	10·6	5·1	1·7	80·2
9. " " . .	15·1	70·0	11·5	1·5	1·9	82·4
10. Malabar	14·7	82·8	1·6	...	0·9	97·0

The astringent character of Pterocarpus kino is very marked according to these results. Including the three samples from the Central Provinces which were collected as an experiment, and were inferior as regards appearence, the average yield of tannic acid in the dry substance is over 90 per cent.

Pharmacopœia tests.

The tests for kino in the British Pharmacopœia for 1898 require that it should " be partially soluble in cold water: almost entirely soluble in alcohol (90 per cent.). Yields little or nothing to ether. Not less than 80 per cent. should be soluble in boiling water." These tests are quite consistent with the above results. The 80 per cent. of extractive matter, which could be equally well separated by means of cold instead of boiling water, together with 15 per cent. of moisture natural to the kino, would leave a margin of 5 per cent. for insoluble impurities.

Gelatinisation of tincture.

The above tests were made on fresh specimens of dried juice, and it is probable that this accounts for their superiority. It is a well known fact that tinctures of kino made with spirit become gelatinised on keeping, due to the formation of a modified form of tannic acid. It might be surmised therefore that the kino even in a dried state is liable to be rendered less soluble when kept for any length of time.

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COMMERCE.

Commerce.—In North Malabar alone about 2,000 pounds of kino can be produced annually, at the cost price of three to four annas a pound. Except for the requisition of the Medical Store Departments of Calcutta, Madras and Bombay, there is scarcely any demand for the article in India.

Exported from Western Coast.

The drug collected in Malabar finds an outlet in the ports of Calicut and Tellicherry. That from North Malabar is shipped at Tellicherry, while that from South Malabar (including the Nilambur forests and the Wynaad), Coimbatore and the Nilgiris would be shipped at Calicut. The Native State of Travancore exports its produce through Cochin and Alleppy, while gum collected in South Kanara would be despatched from Mangalore. Coasting steamers and country sailing boats called *bugalows* collect products at all the Travancore and Malabar ports and convey them to Bombay. The trade is in the hands of European and native firms and would account for so much of the kino being called "Cochin grain," as Cochin is the principal port of call, though not necessarily the port at which the kino is shipped.

Origin of term "Cochin grain."

The drug is always exported in a dried state, since it has been found by experience that it is quite unsaleable in the fluid condition.

The last few years have witnessed a great fluctuation in the price of kino in the London drug market.

Advantages of a local market.

In October 1874 the price of kino was quoted in London at £3 to £5 per cwt. (6·4*d.* to 10·7*d.* per ℔). In 20 years afterwards, it suddenly rose to £20 to 30 per cwt. (3*s.* 6*d.* to 5*s.* 4*d.* per ℔ and then to 16*s.* to 17*s.* per ℔, at which price it remained for sometime.

In March 1894, Dr. J. Parker, the Medical Store-keeper, Bombay, found he was unable to obtain kino in the local market in sufficient quantity and at a reasonable rate, and accordingly entered into negotiations with the District Forest Officer, North Malabar. Mr. Marshall, the Forest Officer, undertook to supply the article to the Medical depôt to the extent required and at the rate of 6 to 8 annas per ℔ in the dried state inclusive of all charges. The estimated annual requirement of kino by the Medical Department of India is about 300℔, which at 8 annas per ℔ costs Rs. 150. Were the drug on the other hand purchased from England, where it is not produced, at the high cost of Rs. 17 per ℔, the price would amount to Rs. 4,371, at 1*s.* 2*d.* exchange.

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PTEROCARPUS Marsupium. **Malabar Kino: Its Collection,**

COMMERCE IN KINO.

Dr. Parker remarked that "this is a striking instance of the financial advantage of procuring whatever drugs are now recognised by the profession and which India may produce direct from their source as far as practicable. Collection under Government supervision is a guarantee of purity, a very great consideration when dealing in drugs, and an article so obtained could be transferred to the Medical Department for the mere cost of collection and incidental charges. The kino supplied from Malabar is of exceptional quality, the best I have ever seen."

Action taken by Forest Department.

The high price of kino continued to be a matter for speculation in England in 1895, and the reason of the monopoly could not be explained. Mr. E. M. Holmes, of the Pharmaceutical Society's Museum, Bloomsbury Square, London, addressed a letter in September of that year to the Reporter on Economic Products, drawing attention to the excessive charges for the gum and its scarcity in the market, and suggesting the despatch through some authorized source of moderately sized parcels of the pure drug. The genuine gum was then selling for 16*s*. per ℔, and astringent gums from other sources were also reserved in the market at high prices. Communication was opened up with the Inspector General of Forests and Forest officers in Southern India which resulted in additional information concerning Malabar kino and a collection of specimens of the drug representative of the various districts where the **Pterocarpus Marsupium** is more or less abundantly produced.

Improvements in manufacture.

It was very evident that the trade at home was in an unsatisfactory condition, and the kino that was sold as such was often adulterated with the gum of **Bombax** and particles of bark and wood, or was carelessly collected in India. In Malabar, where the trees are plentiful, special attention has been given during the past few years to the preparation of the kino, and many important improvements effected in the manufacture, which have brought the article to a state of almost absolute purity. The gum was also collected in other districts by Forest officers who recognised the importance of the industry. Specimens were sent to the Imperial Institute for examination and opinion, and were handed over to trustworthy brokers for valuation. The reports being favourable, further consignments of excellent gum in larger quantities were despatched to London, and the desired result was attained in securing reasonable prices for consumers.

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During 1896 the price of kino in London declined to 12*s.* and 11*s.* per ℔, although many holders of the gum held out for higher prices. The result was that the drug became very much neglected and the stocks remained unsold. COMMERCE IN KINO. Prices in 1896.

In 1897 and 1898 very slight depression was noticed in the market; the price for genuine "Cochin" grain was 10*s.* per ℔, and it was reported that there was a scarcity of the true kino. 1897-98.

During 1899 there was a remarkable fall in the value, and the prices realised for Cochin gum as the year advanced were 10*s.*, 8*s.*, 7*s.* 6*d.*, 6*s.*, 4*s.* 6*d.*, 3*s.*, and 2*s.* The deliveries were good at the end of the year, and the large stocks became greatly reduced. The lowering of the value continued in 1900 and in one of the last reports (May 26th, 1900) it is stated "6 cases Cochin sold very cheaply at 1*s.* per ℔." 1899. 1900.

This most desirable result of reducing the price of kino to its normal valuation has no doubt been attained by the reasonable action of the Forest Department in India.

The two following reports by Professor Wyndham R. Dunstan, F.R.S., Sec.C.S., Director of the Scientific Department, on samples of Indian kino sent to the Imperial Institute in 1898, serve to illustrate the commercial position of kino:— Report from Imperial Institute.

REPORT I.

This sample was received with Dr. Watt's letter of April 29th, 1898, having been forwarded by the Inspector General of Forests to the Government of India with a letter dated the 17th March 1898. In the letter of the Inspector General it is stated that the kino from North Malabar is probably of first-rate quality and likely to command a high price in the English market, although samples which were sent to a firm of manufacturing chemists in London had not been reported on favourably.

The present sample shows all the characteristics of the kino prescribed for use in medicine in the last edition (1898) of the British Pharmacopœia. In order to obtain reliable information as to its probable commercial value, a part of the sample was submitted to a well-known firm in the city who deal largely in this material. They report that the substance is genuine kino of excellent quality. With reference to its commercial value, they make the following statement, which shows that there have been great fluctuations in the Kino of excellent quality.

COMMERCE IN KINO.

price of this drug within recent years. About seven years ago several hundredweights were sold at the rate of 37*s*. 6*d*., that is, for about 4*d*. per ℔. After the drug had been in stock for nearly two years, most of it was re-sold for £16 a hundredweight, that is, about 2*s*. 10*d*. a ℔. Somewhat later the drug became very scarce and the price gradually rose to 16*s*. per ℔. At the present time the price is still high, kino having been sold for 13*s*. per ℔ within the last few weeks. If, however, any large quantity of the drug were put on to the market, the probability is that the price would again fall to its average value of from 6*d*. to 1*s*. a pound. Having regard to the facts stated in **Dr. Watt's** letter that kino can be profitably collected at a cost of 8 annas per ℔, and to the statements of the commercial experts referred to above, the most desirable course for the present would seem to be to place relatively small parcels of the drug periodically on the English market, without, however, greatly augmenting the exports to this country. If necessary, this Department would be glad to assist the Inspector General of Forests in placing consignments with trustworthy brokers in this country.

Fluctuation of the market.

Report II.

Second Report.

This sample of kino, from **Pterocarpus Marsupium,** grown in the Chanda Division, Central Provinces, is that referred to in **Dr. Watt's** letter (F. S. No. 3039—43, dated 17th November 1898). In order to compare this sample of kino with the kino derived from the Malabar forests in Madras, a chemical analysis of it has been made with the following results :—

Moisture	16·23 per cent.
Substances insoluble in water	10·28 ,,
Tannin (absorbed by hide powder)	84·69 ,,

From these results it is clear that the Chanda kino has very much the same composition as that from Malabar.

Inferiority due to appearance.

Although the kino answers all the tests of the British Pharmacopœia, it is very inferior to the best kino in appearance. The fragments are smaller, duller, and darker in colour, which will probably detract from the commercial value. It is probable that these defects are due chiefly, if not entirely, to careless preparation, especially from overheating in drying the material.

I have already discussed the commercial position of kino in a previous report, dated 14th June 1898, and it still commands a high

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COMMERCE IN KINO.

price in the English market. It would therefore seem to be worth while to submit for examination another sample of Chanda kino more carefully prepared.

Remedies for improving the market.

I may add that a commercial expert, whom I consulted on the general question of kino, suggested that it would be more profitable to the producers if Indian kino of uniform quality were sent to England and consigned to one drug broker only. If this were done it is stated that a better price would be obtained for the material. It is thought that so long as indiscriminate shipments are made by any one, and forwarded to various brokers in this country, that the price of kino will fluctuate very greatly, and may on some occasions fall as low as 37*s*. 6*d*. per cwt.

DYEING.

Dye and Tan.—The bark is occasionally employed for dyeing. Mr. (now Sir Thomas) Wardle, of Leek, found it to contain a brownish-red colouring matter, which produced reddish-fawn colours with tassar silk. The gum might also be used for this purpose if it could be procured cheap enough. The gum is also used in the manufacture of certain wines, and it is believed that most of the kino now exported is used in this connection.

Tanning material.

The bark is used for its astringent properties in the territory of Goa; and a decoction of the bark has been forwarded from Coorg as a desirable tan liquor. A sample of the thick bark (Register No. 10585) taken from trees in Chanda, Central Provinces, had the following composition:—

Tannic acid	5·4
Water extract	7·0
Moisture	10·2
Ash	12·9

The proportion of water extract in the bark is low, but the percentage of tannic acid in the extract, estimated by means of hide powder, is 77·1.

MEDICAL PROPERTIES OF KINO.

Medicine.—Rumphius is perhaps the first writer on the East to notice the medicinal properties of the gum. He remarks that the gum looks like dried blood and cures diarrhœa; he also says that the bruised leaves are applied to boils, sores, and skin eruptions. Ainslie (*Materia Indica*, II, 264) refers to the occurrence of Pterocarpus Marsupium on the Coromandel Coast, and relates that the bark and gum are supposed by the natives to have virtues in tooth-ache. The exudation from a species of Pterocarpus called draco growing in

PTEROCARPUS Marsupium. **Malabar Kino: Its Collection, Composition and Trade.**

MEDICAL PROPERTIES OF KINO.

A powerful astringent.

Java, yields red gum which is considered tonic. Dr. Ainslie defines kino as a powerful astringent, and employed with success in *fluor albus*, chronic diarrhœa, and uterine and intestinal hæmorrhages. That from Malabar, however, is chiefly reserved for the European market, and Butea or *Palas* kino is employed in native practice. From whatever source obtained, kino is milder in its action than catechu, probably on account of the phlobaphene it contains, and is, therefore, better adapted for children and delicate patients.

OTHER USES OF THE TREE.

Fodder.

Fodder.—The leaves are an excellent fodder for cattle and goats, and are much in demand; indeed, cattle-keepers are said to often do great damage to the trees.

Green manure.

Manure.—The leaves of this tree are reported by Mr. Mollison to be especially valuable as a manure. An analysis of the green leaves and twigs made by Dr. Leather shows that they contain 21·23 per cent. of dry matter consisting of 19·58 per cent. of organic substance, 0·53 per cent. of potash, 0·05 per cent. of phosphoric acid, and 0·45 per cent. of nitrogen. The leaves also possess an astringent principle which according to Mr. Mollison would repel or destroy insects and grubs harmful to growing crops.

Timber.

Timber.—Sapwood small; heartwood brown, with darker streaks, very hard, durable, seasons well, and takes a fine polish; it is full of red gum resin and stains, yellow when damp; weight 47℔ to 52℔ per cubic foot.

Suitable for out-door work.

Vengai affords an invaluable timber in Western and Southern India; being unaffected by the heat of the sun or dampness, it is suitable for out-door or in-door work. Owing to the large amount of resinous matter it contains it is not attacked by white ants, and other insects. It has a good fracture, exhibiting a wiry splinter, and the wood is eminently suited for ordnance requisites. It is much used for door and window frames, posts and beams, furniture, agricultural implements, cart and boat building; and has also been employed for sleepers. Twenty-five sleepers, which had been down seven to eight years on the Mysore State Railway, were found, when taken up, to comprise nine good, eleven still servicable, and five bad; sleepers of this timber have also been used to a certain extent on the Holkar and Neemuch and other lines (*Gamble*).

Used for railway sleepers.

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REH.

[*Dictionary of Economic Products, Vol. VI., Pt. I., R. 67-70.*]

An account of the attempts which have been made to utilize the upland barren lands (usar) of the North-Western Provinces and Oudh for profitable purposes. By W. H. MORELAND, ESQ., *Director, Department of Land Records and Agriculture, North-Western Provinces and Oudh.*

PREFACE.

The draft of this note was circulated to a large number of officers for criticism, and I desire to express my obligations to all those who have been kind enough to assist me.

The botanical nomenclature follows that of the Flora of British India, so that many plants appear under names differing from those which were used in the older reports. In such cases the synonyms have been given in foot-notes.

CHAPTER I.

Introductory.

AREA OF BARREN LAND IN N.-W. PROVINCES AND OUDH.

The area of barren land in these Provinces is returned at 8,880,959 acres, which is classified as follows :—

	Acres.
Land covered with water	2,847,685
Land occupied by houses, roads, etc. . .	2,884,255
Land barren for other reasons . . .	3,149,019

The two former classes are not available for agricultural purposes, and the problem which has been the subject of special study by the Agricultural Department for the last twenty years is the utilization of

TWO KINDS OF BARREN LAND.

Cause of barrenness

the three million acres included in the third class. All of this land is not rendered barren by the same defects, but there are no accurate statistics of the area which suffers from each cause. Leaving out all minor subdivisions, the barren land may be classed as due either to the effects of erosion or to the want of drainage, the latter cause accounting for considerably the greater proportion of the area.

First kind—ravined.

Land which has been rendered barren by erosion can usually be identified at a glance : the surface is broken by water channels, and there is an entire absence of soil in the strict sense of the word ; the soil has in fact been washed away, and the surface of the land is composed of clay sufficiently tenacious to resist for a time the action of running water. In some cases however the nature of the defect is not so apparent, and the barren tract would at first sight be classed as *usar* in the current use of that term. This occurs where the land through which a stream passes has originally had a more or less regular subsoil of hard clay; as the stream gradually wears a bed through this, everything on the surface is washed down and the clay subsoil exposed. The resistance of the clay prevents the stream from cutting a deep bed, and consequently the process of ravining can take place, if at all, only on a very small scale; but any attempt at cultivation in the ordinary way is doomed to failure, as the tilth is washed away as soon as produced.

Some forms might pass for usar on casual inspection.

Experiments on the utilization of ravine lands have ceased for some years as far as this Department is concerned. The results attained are discussed in *Chapter V* of Dr. Voelcker's *Report on the Improvement of Indian Agriculture*, and need no further reference in this note. The subject has been mentioned only in order to point out that some land which would ordinarily be classed as *usar* must be regarded as ravined, and utilized by the methods which have proved successful in such land, and not by those which are recommended further on for the treatment of *usar* in the strict sense. Lands of this class can be recognized with a little care : if a piece of barren land is seen where the marginal fields are somewhat above the level of the barren land and where the land slopes down to a well-defined water channel, the even surface being usually broken by low, abrupt mounds of hard clay or nodular limestone, then that piece of barren land may be attributed to the action of erosion, and may be treated by one of the methods recommended for utilizing ravined land.

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Upland Barren Lands (Usar). (*W. H. Moreland*) | REH.

The second class—land rendered barren by want of drainage or by excessive flow from above—may be further subdivided into (1) the lowlands along rivers and (2) the uplands. The main characteristic of the first subdivision is wetness through a large part of the year; the land being little, if at all, above the level of the river can never be thoroughly drained; and it receives additional supplies of moisture from the soakage of the higher ground.

TWO KINDS OF BARREN LAND. Second kind—by want of drainage. Its two subdivisions—lowlands and uplands.

The fertility or barrenness of these lowlands is largely a question of season. After a year or two of scanty rainfall much of the land will be found bearing luxuriant crops or at least abundant grass, while after a series of wet years (such as occurred from 1892 to 1894) the land will be unproductive and parts of it will be thickly crusted with the deposit of soda salts popularly known as "*reh.*" The probable origin of this deposit will be explained further on; but here it is sufficient to say that the reclamation of such land can be effected, if at all, only by the engineer. The example of the Kali Nadi works in the Bulandshahr district shows that where it is possible to re-align the river channel so as to secure a more rapid flow of water the amount of infertile land can be greatly reduced; but such action is possible only in comparatively few cases, where the river-bed has become obstructed or tortuous and where the river itself is of moderate size. Where these conditions do not exist agricultural science can suggest no practical remedy. All that can be done is to maintain a careful watch over the tracts likely to be so affected, and to adjust the revenue demand to circumstances. If the demand imposed in years of prosperity is collected in bad times, the owners and cultivators become impoverished and are unable to resume cultivation when the seasons change: if the demand is varied in accordance with the productivity of the land, the recovery is often rapid and the land may afford a valuable resource in times of drought when the uplands are too dry for cultivation. The need for watchfulness in such cases is well known to experienced revenue officers, and the organization for securing early information of injury has recently been perfected. Similar in nature to the lowlands are those tracts which have been swamped by excessive supply of canal water. Where the level of a canal is high and the subsoil retentive, or there is an impervious stratum of soil near the surface of the ground and running under the canal, the land in the immediate vicinity tends to become swampy; and even where swamps do not actually form the rapid evaporation

LOWLANDS WANTING DRAINAGE.

Fertility of lowlands varies much with season.

Re-alignment of rivers may in some cases improve them.

When this is impossible it remains to adjust the revenue to season.

Conditions leading to swamping with canal water.

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LOWLANDS WANTING DRAINAGE.

from the surface, and the constant upward movement of water from the excessive supply so near the surface, tend to bring up all the soluble salts and accumulate them at the surface, thus giving rise to the formation known as *reh*. The danger of over-saturation is fully recognized by the officers of the Irrigation Department, and most of the affected tracts have been relieved by drainage works, which are known to be an effectual remedy. The remainder of this note refers not to the river valleys nor to the over-saturated areas, but to the land which is rendered barren by other causes.

Adjustment by drainage.

UPLAND BARREN LANDS.

Distribution of upland barren lands

It may be estimated that the upland barren lands extend to about two million acres; they are to be found mainly in the country between the Jumna and the Ganges and between the Ganges and the Gogra. Two particular tracts may be defined in which the barren area forms an exceptionally large proportion of the total. The first of these extends from Aligarh to Allahabad, including the districts of Aligarh, Etah, Mainpuri, Farrukhabad, Etáwah, Cawnpore, Fatehpur, and Allahabad, the proportion reaching a maximum in Mainpuri. The second tract extends from Hardoi to Azamgarh, and includes the districts of Hardoi, Lucknow, Unao, Sultanpur, Partabgarh, Azamgarh, and the north of Jaunpur.

FIRST FORM OF UPLAND BARREN LAND—USAR.

The barren land in these tracts is not continuous; it occurs in patches, varying in size from a few square yards to a square mile or more, and its distribution is most irregular. To the eye it presents one or other of two typical forms, which however are not opposed but are the extremes of a continuous series. The first form is usually spoken of as *usar*,* and shows in dry weather an extremely hard compact surface of a colour varying from light to dark grey: here and there may be seen a single *babul* or a stunted *nim* tree, but as a rule the vegetation is limited to scanty grass, usually of the "typical *usar* grass" (**Sporobolus arabicus**, *Boiss.*)†: other grasses of a somewhat better type are occasionally found, though not in sufficient abundance to afford grazing of much value. During the rainy season the land takes a much darker colour, due to the moisture in the surface

* The words *usar*, *reh*, *kallar*, etc., are occasionally used somewhat loosely in the literature on the subject. In this note I have used the term "*usar*" in the general sense to denote all barren land other than the classes which have been excluded in the preceding paragraphs. The term "*reh*" is limited to the alkaline efflorescence. *Rehi* or *rihála* mean land bearing *reh*; *kallar* is applied by some to unefflorescent *usar*, but more properly to eroded land.

† Formerly called **Sporobolus pallidus**, *Benth.*

SECOND FORM OF UPLAND BARREN LAND.

soil: after heavy rain the water stands on the surface, being unable to soak into the soil, while the wet surface layer becomes so slippery that it is difficult to maintain a foothold. During this season the coarse grasses spring up rapidly and are used for grazing; but they die down very quickly in October, or earlier if September is dry, and though the cattle are turned out on the land during the rest of the year, the grazing is of the poorest description.

In the second form the land in the dry season is covered, more or less irregularly, with a crust of white salts, which in the worst places may extend to a depth of some inches. Vegetation is similar in kind to that seen on the first form, but is still scantier and is absent where the efflorescence is well defined. During the rains the salts entirely disappear, and the surface of the land is seen to be similar to that of the first form.

The marked external features of the barren lands soon attracted official attention, and various investigations have from time to time been set on foot. It will be convenient to give in this place a brief account of the more important literature on the subject.

CHAPTER II.

The Literature of the Subject.

THE LITERATURE OF BARREN LANDS. Sleeman's description.

The earliest discussion of the barren lands which I have been able to discover is contained in Sleeman's journal of his tour through Oudh, published in 1858, but written eight or nine years earlier. He describes the *usar* plains of South Oudh, offers a theory which in essentials is not very far from being in accordance with the views that now find acceptance, and gives an account of the methods of reclamation that were practised by the people. The next important steps in the investigation of the subject are detailed in the "Correspondence relating to the deterioration of lands from the presence in the soil of *reh*," which was published in 1864 as No. XLII *of the Selections from the Records of the Government of India.* This correspondence deals with the deterioration of certain villages lying along the Western Jumna Canal, and it shows clearly that while the canal was not responsible for the presence of injurious salts in the affected tracts, its construction and the neglect of the necessary drainage works had led to the accumulation of the salts at the surface in such quantities as to render cultivation impossible. The correspondence therefore deals

Correspondence on the result of over-saturation from the Western Jumna canal.

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THE LITERATURE OF BARREN LANDS. **Revenue Settlement of Western Doab resulting in planting experiments in Aligarh and some silting experiments.**

directly with the results of canal over-saturation, but indirectly it contains valuable materials for the general study of the formation of alkali.

No record of investigations during the next ten years has come to my notice, but in the early seventies, when the districts of the Central Doab were under settlement, the question naturally came into prominence, and a set of enquiries on the subject was circulated to revenue officers. The replies were issued in 1874 with a note by Mr. (now Sir Edward) Buck, and minutes by the Members of the Board of Revenue. I cannot find that any immediate action was taken as the results of these enquiries beyond the formation of a plantation at Pardil Nagar in Aligarh and some silting experiments which were carried out by the Irrigation Department; but the subject was reopened in 1876 when a planter complained that his lands had been injured by the mismanagement of canal irrigation. A committee was then appointed to examine the whole question, and as the result of their enquiries a scheme of experimental work was drawn up to be carried out mainly by the newly-formed Agricultural Department, and to include arboriculture, surface and subsoil drainage, flushing, manuring, and the growth of special crops. The discussions of this committee led to no conclusion on questions of theory; but it is worthy of note that the theory of alkali stated by Mr. H. B. Medlicott, then *Superintendent of the Geological Survey* and one of the members of the committee, is that which now commands universal acceptance.

During deliberations of Committee of 1876 Medlicott put forward the accepted theory of alkali.

The deliberations led also to the carrying out of experiments to be described.

The scheme prepared by the committee was carried out with some occasional breaches of continuity and is now completed. The work done and the results obtained will be detailed further on; but it may be pointed out in this place that the value of the work would have been greatly increased if analyses had been made of the soil of the plots on which the experiments were made; if such analyses were made there is now no record of them, and it is thus sometimes difficult to form an accurate opinion of the results, or to apply them to other land intended to be reclaimed. This defect was pointed out in paragraph 78 of Dr. Voelcker's *Report on Indian Agriculture*, and as one result of his enquiries, an Agricultural Chemist (Dr. J. W. Leather) was brought on the staff of the Imperial Department and his services made available for these investigations.

Dr. Leather's chemical investigations follow.

Some results of Dr. Leather's chemical investigations have been published in *The Agricultural Ledger* (Nos. 12 and 13 of 1893 and Nos. 7 and 13 of 1897); but no detailed account of the agricultural

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THE LITERATURE OF BARREN LANDS.

work of the last twenty years has been prepared, the subject being noticed at greater or less length in the annual reports of this Department. The details given in these reports and such other information as was on record have now been brought together; but they may conveniently be prefaced by a brief account of what is known regarding the accumulation of alkali at the surface of the soil. As already indicated, the main theory was clearly stated by Mr. Medlicott; the earliest suggestions for the chemical treatment of alkali were made by Dr. Brown and by Dr. Romanis, the Chemical Examiner of Burma, while Brown and Center first advocated systematic tillage and the use of organic manures. Center's paper is printed in the Dictionary of Economic Products. Subsequently the limited number of scientific men in the country appear to have turned their energies in other directions, and the later investigations on the subject have for the most part being the work of Professor E. W. Hilgard and his colleagues on the staff of the *California experiment station*; it is unnecessary for my present purpose to give references to the original papers, as the subject is clearly explained in the last chapter of Professor Warington's "*Lectures on some of the Physical Properties of Soils*" (*Clarendon Press, 1900*), and in a summary of the work in California printed as *Bulletin No. 128 of the Californian experimental station*, for copies of which I am indebted to Professor Hilgard. Some of Professor Hilgard's papers have been reviewed in *The Agricultural Ledger* (see No. 1 of 1896 and No. 4 of 1901).

Various scientific men have turned their attention to the question.

CHAPTER III.

The Accumulation and Movements of Salts in the Soil and their Effects on Vegetation.

SALINITY OF SOILS.

The results of scientific investigation may be shortly summarized as follows. Practically all soils contain the materials which go to form the salts known collectively as *reh* or alkali. The principal base of these salts is soda, which is combined with chlorine or with sulphuric or carbonic acid, forming sodium chloride (common salt), sodium sulphate, or sodium carbonate. A certain amount of some of these salts is to be found in the soil at any given moment, but this amount does not by any means represent the total of salts which can be produced. Most soils contain a considerable proportion of complex silicates, of which soda is a usual ingredient. These

Chief salts in soils.

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SALINITY OF SOILS.

silicates are in their original forms insoluble in water or weak acids; but they slowly decompose by the weathering action of sun, air, water, and carbonic acid, into simpler substances, including soda salts soluble in water. There is thus a continuous addition to the soil of soluble soda salts; and if no natural means existed for the removal of these salts, they might in time so far increase as to render the land unfit for cultivation.

Their continuous formation and accumulation if not removed.

In ordinary culturable soils these salts are removed by drainage.* They are extremely soluble in water, and as the rain water soaks through the soil, it washes the salts out and carries them in solution until they eventually reach the sea. Thus there is, in the case of ordinary soils, no accumulation of these salts, which are removed, roughly speaking, as fast as they are formed. If, however, the soil is so constituted that water cannot drain through it, because either (1) an impermeable layer underlies a porous soil, or (2) the texture of the soil is such as itself to form an obstacle to percolation, or (3) the water in the subsoil stands high, no means exist for the escape of the salts and they must accumulate in the soil.

Conditions leading to accumulation of salts in the soil.

Their vertical distribution changes with climate.

In such cases the vertical distribution of salts in the soil depends mainly on the climate. When rain falls it dissolves all the salts at the surface, and carries them downwards as far as it is able to penetrate; but in dry weather water is evaporated from the surface and its place supplied by water from below which is brought up by capillary attraction, so that there is a stream of water flowing from below towards the surface. This stream carries with it all the salts which it has dissolved on its downward or upward journey, and brings them near to the surface: when it evaporates it deposits them at the surface. The question then whether in such undrained soils salts will accumulate at a particular level, or will be distributed more or less evenly through the mass, depends firstly on the nature of the climate; where an island climate prevails, that is where there is moderate heat broken by frequent showers, there will not be any great accumulation of salts at any particular level; but in a continental climate with great heat and either scanty rainfall or rainfall which though heavy is confined to a short portion of the year, the salts

* Muttra and parts of adjoining districts are interesting in this connection. The soil is porous and there is no *usar*, but apparently the drainage has not a free escape, and in many places the well-water contains soda salts in solution to an extent that entirely prevents its use for irrigation.

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SALINITY OF SOILS.

will have time to come to the surface, which will be richer in them than the lower layers.

Conditions which influence movement of water in soils, and therefore accumulation of salts.

Climate then is one controlling factor; but the rate of accumulation of the salts is affected to a very important extent by the condition of the surface of the soil and by the size of its particles, as these affect the rate of evaporation. Evaporation is greatest from a bare and hard soil, and the rate can be reduced either by maintaining vegetation at the surface or by keeping the top layer of soil in a condition of good tillage. The size and packing of the particles of the soil determine the rate of capillary movement. In a sandy soil, with coarse particles loosely packed, water can rise to the surface only very slowly; but in compact clay soils the rate of movement is much more rapid, and water comes freely to the surface. The total evaporation from such surfaces is consequently very great, and as the amount of salts brought to the surface must depend, *Cœteris paribus*, on the amount of evaporation, it is clear that the hard compact clays with bare surface will accumulate most salts.

An accumulation of soda salts in the land starves the plants on it.

It is a matter of common knowledge that any considerable proportion of soda salts is injurious or fatal to plant life. It seems that the injury is due mainly to the high degree of concentration of the salt solution which is in contact with the roots, and extracts the moisture from the plant instead of adding to its supply: the plant is thus starved. The question has not apparently been fully studied in this country.

The percentage of salts which ensures sterility varies according to the nature of the plant. Professor Hilgard's *Bulletin No. 128*, already quoted, gives the following facts ascertained in the California stations. The percentage given is for the first four feet of soil.

Different plants differ in tolerance of this accumulation.

Barley failed to grow where the total salts were 0·203 per cent., but gave a full crop where they were 0·159 per acre (half of which was carbonate). Wheat is rather more sensitive: maize fails on slightly alkaline land; but certain sorghums do well on mild white alkali (*i.e.*, not containing much carbonate): a near relative of **Eleusine coracana**, *Gaertn.*, (our *mandwa*) was most successful on land containing 0·075 per cent. of alkali; and **Pennisetum typhoideum**, *Rich.*, (our *bajra*) succeeded on land containing 0·056 of alkali. *Leguminosœ* were found more sensitive to carbonate, while fairly tolerant of other salts: lucerne does best of this order if it gets a good start. (*See The Agricultural Ledger No. 4 of 1901, pages 47-49.*)

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Tolerance of plants has been thus tested in India.

Dr. Leather's results in this country are given in *Agricultural Ledger No. 13 of 1897*. In pot experiments he found that germination of ordinary crops was possible at least up to 0·4 per cent. of carbonate and to 1·0 per cent. of sulphate and chloride. In aftergrowth 0·2 of carbonate was harmful, while 0·4 was generally fatal. The results with chloride were not uniform: sulphate was less harmful than either carbonate or chloride. The Leguminous plants gram, (**Cicer arietinum**, *Linn.*) peas, and *arhar*, (**Cajanus indicus**, *Spreng.*) suffered most. Of the cereals, maize was least affected—a result which may possibly be attributed to the difference of season. Analysis of samples taken from cultivated fields showed that wheat grew well in the presence of 0·137 of carbonate, but was destroyed by 0·2 per cent.

Different salts differ in degree of harmfulness.

On the whole the following conclusions may be drawn:—

(*a*) Carbonate is most harmful and sulphate least harmful.
(*b*) Legumes are more affected than cereals.
(*c*) A proportion of 0·2 per cent. of carbonate in the soil around the roots is fatal to cereals.

The reasons why carbonate is more injurious than the other salts are stated to be (1) its greater corrosive effect on the bark of the plant and (2) its action in "puddling" the soil and rendering it difficult of tillage.

CHAPTER IV.

The Nature of the Usar *Soils in these Provinces.*

NATURE OF USAR SOILS.

Classification best by percentage of salt present.

Classification.—Before applying the results of the investigations described in the last chapter to the barren lands of these Provinces, it will be well to give a somewhat fuller description of their physical and chemical characteristics to supplement what has already been said regarding their general appearance. The barren uplands have, it will be remembered, been divided into two classes, according to the presence or absence of alkali efflorescence; but this classification is made for descriptive purposes only. Efflorescence depends on the quantity of salts at the surface of the soil, and this quantity differs from plot to plot, so that the barren lands should rather be regarded as arranged in a series according to the amount of soda salts which they contain, an amount which on the one hand may reach or exceed 3 per cent. in the first six inches of soil, or which on the other hand may not be more than is consistent with thriving vegetation. A more practical preliminary classification would there-

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fore depend on the total amount of salts within reach of the surface (the method followed by Hilgard *in California*). The first class would then consist of soils where the total amount of salts is not excessive and consequently reclamation can be effected by altering the distribution of the salts, or in popular phrase "keeping the salts down". The second class would include those soils where the amount of salts is so great that the removal of some portion, or their conversion to a less noxious form, is a necessary preliminary.

Physical characters, chief one—impermeability.

Physical character.—In all cases the barren lands are found to have one leading characteristic—the impermeability of the soil for a varying depth below the first few inches. Examination of the subsoil by means of pits shows that the upper layer consists of extremely fine clay (using this term in the popular and not the chemical sense), with practically no fissures except where ants or worms have established themselves: animal life however is not found where the surface is very alkaline. The depth of this layer of clay varies from as little as half a metre to three metres (in cases where the pit has been sunk so deep): below the layer of clay is usually found a coarser material, often of a yellowish colour. The clay is for all practical purposes impermeable by water, while the coarser layer is more or less porous. The form of impure calcium carbonate known as "*kankar*" (nodular limestone) is generally, but not universally, found in the layer of clay at varying depths and in varying amount: sometimes these are merely small scattered nodules, while in other places the formation is so thick and continuous as to practically form a rock; it is from the latter formation that is derived the "block *kankar*" which is used for pitching bridge piers and embankments. The depth to which *kankar* may be formed is not known. The professional *kankar*-diggers do not as a rule look for it below four feet,—the length of the *seet* or iron sounding rod which they use. I have found it with a similar rod as deep as two metres, while exposed sections on river banks in some cases show successive layers of the same formation; and records of deep borings show that *kankar* reefs are met with at intervals throughout the alluvium.

Depth of soil.

Presence of Kankar.

An illustration of the impermeability of usar soil.

The impermeability of a hard *usar* may be illustrated by the following note of observations made at the Juhi reserve. A plot of land was covered by a thatch in June 1900, and surface flow on to it was prevented by a border of sheet iron sunk two inches deep. This plot remained covered till August 30th, 1901. During August there had

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THE FEATURES OBSERVED IN USAR SOILS.

been very heavy rain and the whole surface of the *usar* was water-logged. Inside the enclosure the ground was hard and dry and almost impossible to dig: down to about 10 inches there was no trace of moisture at a foot from the edge of the enclosure. Outside the enclosure the ground was soaked to 11 or 12 inches: below that it was dry and crumbly: or in six weeks of heavy rain percolation had reached downward only to the bottom of the grass roots.

The following notes of a continuous series of observations on barren land made between November 1899 and January 1900 during a tour in Cawnpore, Fatehpur, and Allahabad may serve to illustrate the foregoing remarks as to the physical conditions which are found in such cases. Fairly complete records were made of 54 trial pits which were sunk one metre or more, except where a hard reef of *kankar* was found at a lesser depth; of these, 26 pits were roughly classed as being in soil obviously alkali and 28 in other soils, the presence of alkali being determined roughly by the eye and the taste.

Want of vegetation.

Of the 26 pits in alkali land, the surface was bare of all vegetation in eighteen cases, while in eight there were scanty tufts of withered *usar* grass. In no case was vegetation copious.

Want of animal life.

Traces of insect life (ants, worms, white-ants, etc.) were entirely absent in fifteen cases and were very scanty in eight. The facts were not noted in three cases. In no case was insect life copious.

Clay.

In all cases the subsoil was a very compact clay; in only four cases was it fairly dry; while in nineteen cases it was distinctly moist, though no rain fell during the tour, and the surface soil was in every case dry.

Kankar.

In nineteen cases the presence of a *kankar* stratum was sought up to two metres, the ordinary sounding rod being used when a reef was not found in the pit. In thirteen cases a reef was found in the first metre, in five cases in the second metre, and only in one case was no reef found.

Nodules of limestone.

Scattered nodules of limestone, known locally as "*bajri*," were found in the clay of the first metre in the majority of cases, but were by no means always present.

Want of drainage.

The drainage facilities were tested in thirteen cases where water was available. In eleven cases no percolation whatever could be detected, while in the other two the clay was very slightly pervious. In both these cases the pits were close to a high level canal, and the water level in the soil was high, the water in adjacent wells standing

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only from six to eight feet below the curb; they were therefore not strictly comparable with the rest of the series in this respect.

FEATURES OBSERVED IN LESS TYPICAL USAR SOILS.

The 28 pits in land not obviously alkali had the following features :—

Traces of *dub* grass (**Cynodon Dactylon**, *Pers.*) were present at the surface of five, inferior grasses (chiefly **Sporobolus arabicus**, *Boiss.*) in fourteen, while nine were quite bare.

Traces of insect life were copious in thirteen, scanty in twelve, and absent in one case only. In two cases observation was not made.

The subsoil was in almost all cases similar in texture to that of the alkali pits; in twenty cases it was equally bad; while in eight cases it was somewhat better.

Kankar reefs were sought down to two metres in sixteen of the pits; in twelve of these reefs were found (in the first metre in seven cases and in the second in five); while in four no reefs occurred. *Bajri* was occasionally, but not universally, scattered through the soil.

Drainage facilities were tested in 11 pits: in eight the subsoil was quite impervious, in two it was slightly pervious, and in one only was it distinctly pervious.

CHEMISTRY OF USAR SOILS.

Chemical character.—It has already been remarked that the soda salts are the distinctive characteristics of alkali land. The following analyses * are reproduced as illustrating the chemical composition

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* In order to make the exact meaning of these analyses clear to the scientific reader, I reproduce the following note which shows Dr. Leather's method of analysis :—

" 100 grammes of the air dry soil is shaken up for about 15 minutes with 500 cubic centemetre of distilled water. The muddy liquid is then poured into a beaker and allowed to settle for ½ to 1 minute, and then about ¾ of the muddy water poured into a second beaker. The residue in the first beaker is stirred and poured on the filter, and the muddy water in the second beaker is then poured on the filter.

" The liquid passing through the filter is at first muddy, and so long as it runs muddy the filtrate must be poured back on the filter. In the case of most soils the filtrate runs clear in a few minutes, but some *usar* soils require as much as three or four days. The soil itself forms the filter bed.

" The filter is made with a funnel in which is placed a flat porcelain perforated disc, on which rests a circle of cotton cloth somewhat wider than the disc. To the funnel is attached a narrow glass tube about eight feet long."

I may add that this method is unsuitable in the hot, dry weather of the plains as during 3 or 4 days the concentration of the filtrate is materially altered by evaporation. I have obtained satisfactory results with a pressure Chamberland filter, provided due care is taken to wash and dry the filter between each analysis.

RESULT OF ANALYSES OF USAR SOILS.

of our barren lands. They were made by Dr. J. W. Leather, *Agricultural Chemist to the Government of India*:—

Soda salts present in parts of Gursikran reserve.

Soil.	Percentage of				Remarks.
	Carbonate.	Sulphate.	Chloride.	Total soda salts.	
Land growing *dáb* grass, surface to $2\frac{1}{2}$ feet.	...	·023	·011	·034	Samples taken in March 1898.
Land growing *dáb* grass, 3 feet to 4 feet.	·065	·085	·029	·149	
Bare land, surface to $2\frac{1}{2}$ feet.	·214	·274	·105	·593	
Bare land, $2\frac{1}{2}$ feet to 4 feet.	·272	·227	·181	·680	
Gandar grass land, surface to $2\frac{1}{2}$ feet.	·026	·054	·005	·085	
Gandar grass land, 3 feet to 4 feet.	...	·056	·175	·231	
Bare land, surface to $2\frac{1}{2}$ feet.	·582	·254	·210	1·046	
Bare land, 3 feet to 4 feet	·321	·054	·081	·456	

Analyses of Usar Soils.

Soil.	Percentage of				Remarks.
	Carbonate.	Sulphate.	Chloride.	Total soda salts.	
Samples of soil (first two feet) from four pits in a plot in Gursikran which was selected for treatment with Gypsum. I	·768	·045	·011	·824	Samples taken in June 1897.
II	·534	·037	·023	·614	
III	·789	·064	·046	·899	
IV	·477	·042	·043	·562	
Sample of the typical soil of the Juhi reserve.	·173	·012	·014	·199	Taken in October 1899.
Alkaline soil at Kakwan, pargana Bilhaur. First 6 inches .	1·064	·013	·042	1·119	
7 to 18 „ .	·261	·229	.009	·499	
19 to 30 „ .	·491	Trace	Trace	...	

RESULT OF ANALYSES OF USAR SOILS.

Analyses of Usar Soils—contd.

	Soil.	Percentage of Carbonate.	Sulphate.	Chloride.	Total soda salts.	Remarks.
Alkaline soil at Barauli in Farrukhabad.	Bare efflorescent— First 6 inches	·087	1·318	Not given	...	
	7 to 30 „	·159	1·388	do.	...	
	Grass land covered with alkali— First 6 inches	·140	1·186	do.	...	
	7 to 30 „	·022	·191	do.	...	

Origin.—Such being the general features of the barren lands, the theory already stated may be applied to them as follows:—

CLIMATIC CONDITIONS TENDING TO FORMATION OF USAR LANDS.

In the first place the climate is obviously adapted to secure the maximum surface accumulation of salts. The heavy rainfall is confined to about three months, and on level land most of it either soaks into the ground or lies on the surface. During the end of September and the whole of October the heat of the sun is very great, and during the rest of the cold weather the heat is at any rate sufficient to maintain a brisk rate of evaporation. Observations of the soil temperature are wanting, but the rate of evaporation is a fact that cannot be disputed.

In this climate then the only chance of washing out the salts as formed is that the soil should be porous; but any one can satisfy himself by a few simple experiments that there is in real *usar* no percolation whatever in the ordinary sense of the term. The water lies on the surface and gradually soaks down to an extent that depends on the nature of the season or here and there finds crevices into which it can percolate, but it practically never gets so far as to escape into the drainage system of the country. Thus so much of the rainfall as has been absorbed is retained comparatively near the surface, and is ready to be evaporated as soon as the rains come to an end.

Again, when the season of evaporation begins, everything tends to its acceleration. The vegetation is either scanty or soon dies down, or if it is in any quantity is grazed by the cattle, and the

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CONDITIONS TENDING TO LOCALISE THE FORMATION OF USAR LANDS.

surface is left bare to the action of the sun. Again, the texture of the soil is specially adapted to further evaporation. Thus the existing *usar* soils are in every way fitted to secure a maximum accumulation of salts at the surface.*

The irregularity of the surface distribution of the alkali has always attracted attention. It may perhaps be explained as in the main the result of two causes—(*a*) difference in the original alluvial deposits, and (*b*) the annually recurring struggle of the vegetation. It is of course impossible to ascertain the conditions under which any particular tract of barren land was formed during the original deposition of the gangetic alluvium; but it may be conjectured that at an earlier period, before the depression of the deltaic region (*vide page 434, "Manual of the Geology of India, 1893"*), the main rivers did not flow in their present deep valleys, but the water had much freer scope to travel over the surface of the plain. Small accidental surface irregularities would then have an important effect in determining the flow and the deposit of silt. If, for instance, pools or backwaters formed where the water, having already deposited the coarser particles of its burthen, became more or less stagnant and yielded up only the finest silt which remained, the conditions would be present for the deposit of the very compact "clays" which form the bulk of the barren lands. The quantity of soda salts in these would depend on the proportion of silicates containing soda, which again would vary according to the origin of the silt, the relative influence of different tributary streams varying at different seasons or in different years. If again these pools or backwaters dried up in the seasons of least flow, whatever soda salts they carried in solution would be added to the soil, and being highly soluble would be carried into it at the next wetting and not washed off the surface.

It seems probable that the clays were formed in something like this manner, and that their composition would vary greatly according

* It is important to bear in mind the distinction between percolation and capillary motion. Water percolates downwards when the particles of soil are not closely packed but leave free passages; when the particles are closely packed percolation is retarded or prevented. Capillary motion of water on the other hand takes place upwards or downwards so as to tend to equalize the moisture in various parts of the mass, and its rate depends mainly on the closeness of the particles and on the difference of moisture content between the different layers. Thus when percolation is impossible, water can *at most* penetrate down until the lower layers are as wet as the upper; that is to say the upper soil cannot be drained.

to the source of the deposit. Once deposited the gradual weathering of the silicates and the nature of the climate would bring the salts to the surface whenever the layer of clay was so thick and coherent as to prevent natural drainage.

CONDITIONS TENDING TO LOCALISE THE FORMATION OF USAR LANDS.

The second cause affecting the surface distribution has been described as the annually recurring struggle of vegetation. During the rainy season most alkali plots are covered with some sort of vegetation. As soon as dry hot weather sets in evaporation brings the salt up, and this tends to destory the plants ; but at the same time the existence of the plants itself checks evaporation from the surface, and thus tends to keep the salt down. The vegetation may therefore be regarded as struggling with the alkali, and small differences in local conditions may accumulate so as to produce a marked result. Indeed one of the chief lessons of the experimental work to be described later on is the importance of giving the vegetation every assistance in its struggle, this being, for instance, the object of the prevention of close grazing. There appears however to be room for more detailed study of the local differences in distribution.

Room for more study of local conditions.

RECLAMATION OF USAR LANDS.

Reclamation.—Turning from these theoretical discussions to the practical question of rendering the land fit for cultivation, we may take it as established that the primary defect is mechanical, the texture of the soil being so close that water cannot drain through and that air cannot circulate. It is true that these mechanical conditions also lead in certain cases to the surface accumulation of soda salts to an extent that of itself is sufficient to ensure sterility ; but this accumulation is the consequence of the texture, which must, therefore, be regarded as the primary evil.

The remedies indicated by general considerations for the two classes of *usars* given at the beginning of this chapter are as follows. For the first class, it will be sufficient to improve the texture of the surface and as deep down as possible : this will allow the water to take the salts further down ; will lessen evaporation and so hinder their rise ; and will allow air to circulate and thus enable some sort of vegetation to grow which will further reduce evaporation and also lead to further improvement of the texture.

Where, however, the total quantity of salts is excessive, *i.e.*, in the second class of *usars*, the first step must be the removal of the superfluous salts, either from the surface or by under-drainage, or their conversion by chemical means to some less noxious form ; and

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when the soil has thus been raised to the first class the treatment indicated above may be applied.

Methods at our disposal for the purpose.

Agricultural science indicates various methods of improving defective texture: the principal are subsoil drainage, deep tillage addition of bulky organic matter (either manures or green crops ploughed in), soil-mixing, liming, and burning. From the account to be given in the next chapter it will be seen that deep tillage, combined with the addition of bulky organic matter, has given satisfactory results; that subsoil drainage has been condemned as unsuitable, though not to my mind on sufficient grounds; and that soil-mixing, liming, and burning have not been fully tried. Burning is not ordinarily a desirable method of reclamation, though I intend to give it a trial; and cost of carriage will usually prevent mixing on a large scale; but liming seems practicable, and it is a little strange that it has not been tried more extensively. Experiments in this direction have lately been started.

CHAPTER V.

Cultivation of Usar.

INDIGENOUS METHODS OF ATTEMPTING RECLAMATION.

Indigenous methods.—Reclamation of *usar* lands is not unknown to the cultivators in places where the pressure on the soil is great. Sleeman has recorded the opinion on this subject which prevailed in South Oudh fifty years ago. When passing from Partábgarh to Rae Bareli he writes :—

"The people say......that *usar* to be reclaimed has to be flooded for two or three seasons by embankments : then well watered, manured and ploughed. All but the very worst *usar* will thus give tolerable crops." *Sleeman's "Tour through Oudh," Volume I, page 224 (1858 edition).*

Flooding and cultivating.

And when passing through Unao he wrote : "Some people said the worst of the *usar* could be cultivated ; others denied it. All agreed that any but the worst could be reclaimed by flooding for two or three years, cross-ploughing, manuring, and irrigating. All the soil is liable to become *usar* if neglected or left fallow for a few years. Certainly *usar* prevails near the high roads where the peasantry are exposed to the rapacity of the king's troops ; and this tends to confirm the notion that tillage is necessary in certain soils to check the tendency of salts to superabundance." *Sleeman's "Tour through Oudh," Volume I, page 277.*

A description of an indigenous method of reclamation is to be

found in paragraph 18 of Mr. J. R. Reid's *Settlement report on Azamgarh*—a district where the pressure on the soil is notoriously excessive. The method consists in retaining the rain water by embankments and growing rice while the land is under water; it is applicable only to the better kinds of *usar*, and its application is limited by the scarcity of water. Mr. D. C. Baillie, C.S., informs me that he has seen most successful reclamation in this way in Partábgarh district; he notes that it is essential that the part of the *usar* embanked be so placed as to receive the surplus rainfall from higher levels. The rainfall on the land itself is not sufficient.

INDIGENOUS METHODS OF ATTEMPTING RECLAMATION.

In Budaun small patches of *usar* are improved by ploughing into them the worn-out thatch of the houses, and the practice is said to be efficacious.

Ploughing in thatch.

The reclamation of barren land formed the subject of the fifth question of those issued by the *Board of Revenue in 1873-74*, and from the printed collection of replies it appears that instances of reclamation were known in many districts, but that reclamation on a large scale had not been attempted. On the whole it is clear that the improvement effected by native methods has been limited to small patches of the better kinds of *usar*, and that reclamation on a large scale has not appeared sufficiently attractive as an investment to landowners who could command the necessary capital.

Reclamation on a large scale never attempted.

An important section of the experiments carried out under the *Reh* Commitee's scheme was directed towards preparing the soil for profitable cultivation by (1) removal of salts, (2) drainage, (3) silting, (4) deep cultivation, manuring, and ploughing in green crops.

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Removal of salts.—This was tried in the Awa estate. The salts on the surface were scraped off before the rainy season, and in the following year the quantity of salts was found to be decidedly less; but the subsequent history of this plot cannot be ascertained, and it is not known whether it was ever cultivated. As indicated at the close of the last chapter, this treatment, while not likely to result in reclamation unless supplemented by improvement of texture, may turn out to be a valuable preliminary process for *reh* land, and the most economical and effective methods will be determined *Departmental Report for 1880-81, Appendix D.*

By removal of salts.

Surface drainage.—Two experiments were conducted at Awa on the effects of surface drainage. In one plot the land was thrown into ridges and furrows, the furrows being 10 feet apart and the ridges

By surface drainage.

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one foot in height at the top of the slope. In the second plot surface drains were dug six feet apart. *Departmental Report for 1880-81, Appendix D.*

Mr. Wilson wrote in 1881:—

"It was hoped that the rain would wash the salt out of the ridges into the furrows and channels. There certainly appears to be more *reh* in the furrows than in the ridges, but the latter are not yet clean enough for cultivation. Indigo and peas were sown on the ridges during the rains: a few seeds germinated, but the plants died before they were six inches high. The ridges were then manured: wheat and barley were sown, but the few plants that appeared very soon died."

Failure of surface drainage.

These plots are again referred to in the report for 1881-82: the ridges were sown in both harvests, but most of the seeds failed to germinate, and the few plants that came up dried when they were only a few inches high. No further reference can be found to this experiment, which was apparently abandoned. The failure to wash the salts out of the ridges may be attributed to two conditions which are to be found in all *usar*—the extreme solubility of the salts, and the impermeability of the soil. Owing to the first condition the salts are dissolved by the first few drops of rain that fall on them, so that most of the salts have already been carried into the surface soil by the time it is moistened, that is before the surface flow of water can begin. That this is the case may be verified by watching the effects of a shower on an alkali patch or by sprinkling it from a watering-can. Once the salts have been carried into the soil, the impermeability prevents any large proportion of them being washed into the drains or furrows. These considerations appear to me to be fatal to the success of any system of surface drainage. *Departmental Report for 1881-82, Appendix II, paragraph 17.*

Subsoil drainage.

Subsoil drainage.—Experiments with subsoil drainage were made at the same time. *Departmental Report for 1881-82, Appendix II, paragraph 19.* Two inch pipes with collars were laid 20 feet apart 2 feet 6 inches to 3 feet deep, and with a slope of 6 inches in 100 feet. In the first season the drains silted up during the rains and the land showed no improvement. The pipes were relaid and the plot flooded with canal water whenever it was available. *Departmental Report for 1882-83, Appendix I, paragraph 12.* The surface was dug to a depth of one foot and a portion of it was limed. Mr. Wilson wrote in 1883:—

"There are signs of the soil having been cleansed to some extent, but it is not yet fit for growing ordinary crops. The extreme

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hardness and impermeability of *usar* soil are against the experiment; and it is moreover one which could not be conducted on a large scale, except at a prohibitive cost."

Improvement due to subsoil drainage.

In the third year the plot was sown partly with rice and partly with hemp, but both crops failed entirely. In the *rabi* season wheat and barley were sown, and though the seed did not germinate at all uniformly, a decided improvement was apparent in parts of the plot, and some of the plants of wheat matured. *Departmental Report for 1883-84, Appendix I, paragraph 15.* Mr. Wilson wrote: "The soil still contains an excess of saline matter, and from a pecuniary point of view the experiment is a failure." It was not apparently continued.

Objections to subsoil drainage.

American experience regards subsoil drainage as an absolute cure for alkali, but the method is considered objectionable, as the drainage which removes the alkali removes also a portion of the other soluble salts which are required for plant food, and it is regarded as a last resort when more moderate treatment has failed or is certain to fail. The method is in accordance with agricultural theory, and I do not think it should be condemned on a single experiment lasting only for three years, specially as its effect should be determined in combination with other methods of improving texture. I am therefore repeating the experiment on a small scale and on modified lines at the Gursikran station. In this experiment the drains have worked well during the first season: rough analyses of samples of the drainage water showed that they contained quantities of soluble salt (almost entirely carbonate of soda) varying from 1 gramme to 4 grammes per litre. It will however be premature to draw any conclusions for some time.

Repetition of experiment.

Silting.

Silting.—Thus it will be seen that the attempts to remove the injurious salts, either directly or by means of water, have so far been a failure. The treatment described as *silting* is a form of soil-mixing which aims, not at removing the salts, but at burying the infected soil beneath an accumulation of silt. This treatment was tried at Awa and also at other places, the latter experiments being placed under the supervision of irrigation officers.

Mr. Wilson describes the Awa experiment as follows:—

"A plot of land was dug to a depth of three feet and all the *kankar* in it was removed. It was flooded with canal water every week when the distributary near it was running. Some hemp, which was sown in a field of good land in the neighbourhood, was

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ploughed into part of the plot. A mixture of wheat, barley, and peas was sown in half of it and mangold-wurzel in the rest, but no crop was obtained. After irrigation the plot was covered with saline efflorescence." *Departmental Report for 1881-82, Appendix II, paragraph 20.*

A short incomplete and unsuccessful experiment in silting.

It will be seen that this was not merely a silting experiment, as deep tillage and ploughing in were also practised. The further history of the plot is not traceable, but the latter experiments show that the process of silting requires more than one year. The whole history of the silting experiments undertaken by the Irrigation Department is not on record in my library, but the following facts show the results of the system.

Other more successful experiments.

Three plots in the Etáwah district were treated by flushing and deposition of silt, and in 1889 Mr. Holderness wrote of them: "Two of the plots may now be considered to have been fairly well reclaimed, the larger of the two having been let at a low rent for five years to a good tenant, and the third, which has been only two years under treatment, is progressing favourably." *Departmental Report for 1888-89, paragraph 5.*

A fuller account of the same plots is given in the report for the following year. *Departmental Report for 1889-90, Appendix C.* About 40 acres of land in Takran was enclosed in 1874 and flooded until a layer of silt, varying from three feet to four inches, had been deposited. In subsequent years occasional flooding appears to have been practised. In 1875 the land was let for R25 rising to R33-5-4, inclusive of water rate, and it continued under cultivation. In 1883 an area of 33 acres was fairly productive; the rest lay higher, and consequently there was difficulty in depositing silt on it. In 1889-90 the land was leased for R96, including water rate: deducting this the net rent of the plot was only R18-8-1. The total direct expenditure was R416, but to this should be added the value of the water supplied, which is not known.

The second plot at Kandan bridge was similarly covered with silt; there was some difficulty in letting it, and cultivation carried on departmentally resulted in financial loss.

A third plot at Turaia bridge was taken up in 1889-90 for similar treatment, but no account of its progress is to be traced in my records.

Silting can have but a limited application.

Silting to a moderate depth may be regarded as a special form of soil-mixing, and its beneficial results will depend largely on the coarseness of the silt. The drawbacks to this form of mixing are (1)

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it can be carried out only where the water-supply is above the level of the land to be reclaimed; (2) it depends on a very plentiful supply of canal water; and (3) the silt must either be of comparatively coarse texture, or it must be deposited in such quantities as practically to form an entirely new soil on top of the *usar*. The method is therefore of very limited application; it can be carried out by the Irrigation Department where the levels are suitable and where there is sufficient water that would otherwise run to waste; and it could be done by landholders if they are allowed to take the surplus water on very favourable terms.

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Soil-mixing.—Along with these experiments may be noticed the trial of soil-mixing started by one of my predecessors at Juhi. A plot of land was prepared for cultivation in the usual way, and one half of it treated with a dressing of three inches of coarse sand (obtained mostly in sinking a well in the reserve). The land was sown with various crops, and the outturn was distinctly better than that of the control plot, while during growth the improvement caused by the sand was very conspicuous. The method is theoretically sound, but can in practice be profitable only when sand *in sufficient quantities* can be obtained near the *usar* and where carriage can be cheaply effected. It should also be noticed that the Juhi reserve is not much infected with alkali, recent analyses showing that chemically there is no reason why cultivation should not be successful: the defect of this land is in the mechanical texture. Soil-mixing has not yet been tried on real alkali land in these Provinces.

Soil-mixing.

Soil-mixing has yet to be tried on real alkali land.

The *optimum* amount of sand is not known: a dressing of one inch depth goes a comparatively little way, but this quantity would require for an acre as much as 3,630 cubic feet, or the load of about 220 ordinary two-bullock carts. (Such a cart will not carry more than about 16 cubic feet.) The expense would thus be prohibitive, except perhaps where carts and bullocks happen to be standing idle; and this method of reclamation is not recommended.

Expense of soil-mixing.

Tillage and manure.—The records of experiments with thorough cultivation are more complete than those which I have recently discussed. The Amramau plot in Cawnpore may first be considered: this plot measured 54 acres, and was acquired in 1882. For the first few years not much was done beyond enclosure to prevent grazing, but in 1885 cultivation was seriously started. Some land was broken up each year, while cattle were kept on the untouched area,

Tillage and manure.

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the produce being sold and the manure utilized for cultivation. The treatment applied was as follows:—In the first year the land was embanked to retain the rain water, and was ploughed to a depth of five inches. Four ploughings were given between June and December. The land was then rolled, ploughed, and manured with from 15 to 22 tons (400 to 600 maunds) of half-rotted cowdung to the acre. In June of the second year the land was ploughed again and sown with a hardy variety of rice. If this succeeded, a further dressing of manure (100 to 150 maunds) was applied in the autumn and barley or peas sown. If the rice failed, the first year's treatment was repeated. In the third year rice was sown again, and uniformly succeeded; it was followed by barley or peas, and these again by ordinary *kharif* crops (maize, *juar*, or *bajra*). After this the land was leased to tenants at about R8 per acre. In 1892, when 39 acres had been successfully reclaimed, the reserve was sold for R2,050 and the balance sheet stood as follows:—

Fertility gained by the method at Amramau.

Capital Account.

Expenditure.	R	a.	p.	Receipts.	R	a.	p.
Price of land and trees	65	12	0	Sale of live stock	2,234	10	0
Enclosure	529	0	0	Value of live stock transferred	1,169	0	0
Live stock	2,241	3	0				
Seed	300	13	0				
Buildings	1,098	10	0	Dead stock transferred	55	0	0
Implements	100	15	0				
Gain on capital account	1,172	5	0	Price of land	2,050	0	0
Total	5,508	10	0	Total	5,508	10	0

Revenue Account.

Expenditure.	R	a.	p.	Receipts.	R	a.	p.
Supervision	1,470	0	0	Rent	582	9	0
Labour	2,942	9	0	Farm produce	839	4	0
Feed of stock	1,091	15	0	Milk	1,616	9	0
Maintenance of premises	136	11	0	Wool, skins, wood, etc.	277	0	0
Miscellaneous	106	5	0	Loss on revenue account	2,432	2	0
Total	5,747	8	0	Total	5,747	8	0

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Possibility of carrying method out to a profit.

Thus the operations involved a net expenditure of R1,260, against which is to be set the land revenue, which would be about R70 per annum. Bearing in mind the disadvantages incidental to such operations carried on by Government—payment of excessive prices and high wages for inefficient work, excessive cost of supervision, and possible peculation—it seems probable that similar operations on the land could have been conducted by a private landowner at a moderate profit.

By neglect the old conditions recur.

The subsequent history of this plot is instructive. The first proprietors were expert cultivators, and in 1893-94 the condition of the land was found to have further improved. Family disputes however ensued, and the land was eventually sold under a decree. It was purchased by a man who knew nothing of agriculture and rapidly fell into neglect: the land was left fallow and the grass closely grazed, so that the improvement resulting from cultivation is being rapidly lost: the soil is being gradually compacted, and is returning to the condition which favours the rise of salts.

Amramau experiment was in a favourable locality.

The method of reclamation adopted in this case was to improve the texture of the soil by thorough cultivation and the addition of organic manures. The result was a practical, and not far from a financial success; and the same method can be recommended with some confidence where similar conditions recur. One very important condition is the manure supply. In Amramau this was secured by maintaining sufficient stock on the land, the produce being easily disposed of in the neighbouring city markets. It is doubtful whether equally good results could be attained in rural tracts, unless special arrangements could be made for marketing the produce of the stock.

Need of water supply.

A second condition is apparently an adequate water supply, as it is important that the land should be kept in cultivation during the *rabi* season. Given plenty of water and manure, with plough cattle strong enough to perform the early tillage, it may be taken as established that this method of reclamation may be applied to land which does not contain more alkali than Amramau; but unfortunately the original condition of the plot is not accurately known. It was taken up before the services of an analyst were available; the officer who was in charge of its reclamation is dead; and statements of work-people cannot be relied on after so long an interval. The land is nowhere spoken of as particularly bad, and alkali is not largely prevalent in the barren land in the neighbourhood; it must therefore be assumed that the proportion of alkali was not exceptionally high.

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RECLAMATION EXPERIMENTS MADE UNDER GOVERNMENT.

Experiment at Cherat.

Similar methods of reclamation were tried at the Cherat reserve in Aligarh. This land was taken up during 1885 and enclosed by a fence. The original intention was to leave the bad land under whatever grass would grow and to plant *babul*, and perhaps other trees, on the better patches. *Departmental Report for 1884-85, paragraphs 28 and 29.* The original condition of the reserve is thus described in one place:—

"Cherat *usar* is situated in a *reh*-infected tract, and under the influence of a raised water level (due in all probability to the canal), and a miserable system of cultivation, *reh* is steadily spreading in the neighbourbood. The Cherat *usar*, when the Department took it over, was thick in many places with a saline deposit."

On the other hand, according to a description drawn up at the time of acquisition, "the greater part of the land is unculturable, almost bare of trees, and covered with *usar* grass. There is very little saline efflorescence on the surface." As at Amramau, no analysis was made of the unreclaimed land, and having regard to the rather conflicting descriptions just quoted, the most that can be said with confidence is that the land was moderately bad, though the discrepancy may possibly be due to the land having been wet at the time of the second observation. After enclosure had continued for five years, and most of the land was yielding a fair supply of coarse grasses, it was decided to attempt the reclamation of part of this reserve by the methods adopted at Amramau. A start was made in 1890 simultaneously with the establishment of a dairy on the reserve, a plentiful supply of manure being thus secured. *Departmental Report for 1889-90, paragraph 9.* The following extract from the Departmental Report for 1891-92 explains the method adopted and the results secured:—

Tillage operations successful.

"In 1890 tillage operations were commenced, and nine acres were brought under the plough; in 1891, 34 acres were further reclaimed, and during the year under report 33 acres more have been broken up. Thus the total area brought under tillage is 76 acres; of this, 43 acres have been yielding very fair *kharif* and *rabi* crops; and of the balance, *viz.*, 33 acres, broken up only since July last, $29\frac{3}{4}$ acres have been allowed to lie fallow, exposed to the atmospheric action, in order to prepare them for *kharif* cultivation next June; and $3\frac{1}{4}$ acres have been thoroughly ploughed and manured with farm yard manure, at the rate of 50 maunds per acre, and been sown with mixed peas and barley. During the year under report, of 43 acres reclaimed up to June 1892, $21\frac{1}{4}$ acres were let to tenants in the beginning of the current agricultural year on an annual rent of R170, or R8 the acre, and the rest are managed under departmental supervision.

Upland Barren Lands (Usar). (*W. H. Moreland.*)

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Crops grown.

"The following table shows the distribution of area during the two agricultural seasons, *rabi* and *kharif*, of the past revenue year:—

Rabi.		*Kharif.*	
Crop.	Area in acres.	Crop.	Area in acres.
Wheat . . .	5·50	Rice . . .	15·19
Barley . . .	6·75	Sugarcane . .	1·06
Peas . . .	1·25	Fallow . .	5·50
Gram . . .	2·50	Let to tenants .	21·25
Fallow . . .	27·00	...	...
TOTAL .	43·00	TOTAL .	43·00

"Of the spring crops wheat did well, the yield being $8\frac{1}{2}$ maunds* per acre in a plot in which bone dust was used as manure and $5\frac{1}{2}$ maunds elsewhere. The yield of peas was very good; but gram gave a very poor outturn. The sowing of barley was delayed till the beginning of December by accumulation of rain water on the fields, and the outturn was only $4\frac{1}{2}$ maunds per acre; but it is believed that barley would do well if it had a fair trial.

"*The kharif crop.*—Of the five varieties of rice crops, two, *viz.*, *sathi* and *syamjira*, were raised on a soil manured with common farmyard manure, while in the case of the remaining three no manure was applied. On the unmanured soil a variety of very fine rice, named "*Hiranj*," was grown, and it gave the largest yield. The grain of this rice, as well as of others grown on the reclaimed *usar*, is not inferior to that of the same varieties grown elsewhere. *Sathi* comes next with respect to outturn; but the quantity of manure used was large, and the financial results less good than in the case of the preceding variety. *Syamjira* and the rest cannot at all be recommended owing to their poor yield.

"The area allotted to sugarcane was $1\frac{1}{16}$ acres. The local variety, called "*Chin*," was planted on two patches, one of which was manured with bone dust at three maunds per acre, and both were treated with farmyard manure, 80 maunds per acre. The crops had not been cut when the Assistant Director visited the reserve, but he considered that they were doing very well. The taste of the cane was distinctly saltish, showing that it is a salt-absorbing plant—a fact of some practical value. Thus where removal of saline matters from soils forms an object, the plantation of sugarcane would not be disadvantageous.† The percentage of sugar in the cane appears

* One maund = $82\frac{2}{7}$ lbs.

† It may be remarked that the presence of any large quantity of these salts in cane juice would make it useless for manufacturing purposes, and the quantity of alkali removed by a cane crop would be comparatively small.

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however to be below the average. It must also be noted that the soil of Aligarh district is not, generally speaking, suitable for sugarcane."

Treatment of bad spots.

The bad spots on this reserve, which resisted the ordinary treatment, were reclaimed as follows :—After enclosure *usar* grass sprang up here and there, then *bat* grass (**Diplachne fusca,** *Beauv.*) was sown artificially and ousted the *usar* grass, establishing a good stand of vegetation and materially changing the appearance of the surface soil. When this stage had been reached the ordinary tillage operations followed. These results are instructive, but unfortunately the *bat* grass will not establish itself without copious irrigation in the hot season—a fact which restricts the practical use of the method.

Much irrigation needed.

In 1892 the cultivated area was 86 acres, of which 28 acres had been let at R215. Shortly afterwards the whole reserve was leased to Mr. Keventer, who took over the dairy which had been established experimentally a few years before. The dairy proved a success, and eventually Mr. Keventer purchased the whole reserve—land, buildings, and stock—at a price calculated to cover all the expenditure incurred by Government from the beginning of operations. The land brought under cultivation continues to be profitably utilized for the growth of fodder crops, and with liberal applications of dung and liquid manure from the dairy has greatly improved in condition. The financial result was satisfactory; but the figures cannot be given in detail, as they are complicated by the extensive accounts of the dairy. *Departmental Report for 1892-93, paragraph 12.*

Experiment a financial success.

Experiment at Gursikran.

The Gursikran reserve was taken up at the same time as Cherat; it included two classes of land—a stiff clay with very little alkali and a clay highly impregnated with soda salts (see *the analyses in Chapter IV*). The former was cultivated without much difficulty and let to tenants at remunerative rents : all it needed was thorough breaking up. The latter has been reserved for growth of grass and fuel trees, and the results of these experiments will find a place in *Chapters VII and VIII.*

All that a part of the land needed was a thorough breaking up.

Experiment at Juhi.

The Juhi reserve also, which is very slightly infected with alkali, has been used for the most part for experiments in producing fuel and fodder, but some portions have been broken up for cultivation. The land when once broken up can be cultivated without much difficulty.

Use of nightsoil.

Trenching nightsoil.—An experiment of interest to Municipalities was carried through in 1886. The Cawnpore Municipality had trenched some barren land with nightsoil, and after most of the

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poudrette had been dug out and sold to cultivators, the land was made over to the Department to bring under cultivation. As a result of frequent ploughing and irrigation when needed, the land was within three years let to cultivators of garden crops at R16 an acre. This experiment is another illustration of the principlés already mentioned that, given plenty of water and of bulky manure, thorough tillage will in time bring all but the worst alkali land into a state fit for cultivation.

RECLAMATION EXPERIMENTS MADE UNDER GOVERNMENT.

Plenty of water, and of bulky manure and thorough tillage.

Some practical success has been obtained in reclaiming moderate *usar* on the Government estates near Soraon in the Allahabad district. Organic manures were filled into pits dug close together, the land was ploughed frequently, and coarse rices and pulses sown. It is now fit for letting at remunerative rates, and the produce during the period of reclamation has paid all expenses. In this case the work was conducted on the lines that an ordinary landowner would adopt, and the results are most encouraging. The soil was originally compact clay, the proportion of soluble salts being from 2 to 4 parts per thousand.

Experiment at Soraon a success.

The difficulty in the way of any large amount of reclamation by methods similar to those which have been described is the limitation of the manure supply. As is well known, most of the cowdung is burnt owing to the want of other fuel; nightsoil from towns is largely utilized for the market gardens in the vicinity, while that from the villages goes to manure the homelands; litter is not available for the cattle, and the waste of organic matter is in general so small that the refuse heaps do not give more manure than is actually required for the existing cultivation. There is therefore as a rule nothing to spare for the improvement of *usar*, and if the available supply be diverted to this object, the general agriculture of the neighbourhood may be injuriously affected to an extent that may counterbalance the advantage of reclamation. This caution is the more necessary because I believe that something of the sort has actually occurred in one case. The problem becomes to find a source of organic matter which can be employed on *usar* without trenching on the existing manure supply. Apparently the problem can be solved by growing coarse crops during the rains and ploughing them in while green.

It is difficult to know whence can come the necessary manure for general reclamation.

Green manuring.—Theoretically this course is obvious: the same defective drainage which keeps the soda salts at the surface must

Green manuring.

RECLAMATION EXPERIMENTS MADE UNDER GOVERNMENT.

prevent any loss of the soluble elements of fertility, so that these soils should be exceptionally rich, and if growth can be induced by any means a fair crop should result. Now in our climate we have the power to induce growth on moderate *usar* during the rains. The salts have then become somewhat more evenly distributed through the soil, and with thorough tillage a crop of some sort can be produced. Whatever is produced, be it crop, weeds or grass, can then be ploughed in before maturity, and this course will improve the texture of the surface and hinder the rise of the salts. The second year of the process will give further benefit, and it should then be possible to get some sort of a winter crop, the shade of which will still further affect the evaporation. In this way it is expected that within three years the land will become fit for cultivation by the ordinary native implements.

Crop for green manure will grow in rains.

I have been assured on the authority of an officer formerly in this Department that this system has been demonstrated a triumphant success where rice has been grown and ploughed in until the required improvement has been achieved; but unfortunately no record of these experiments is to be found in my office, and as all the cultivated *usar* in my charge has been otherwise accounted for, it would appear that the experiments were not conducted on the reserves under this Department. I cannot therefore give details of the processes actually followed, but the experiment so suggested is now being tried. During the last year a successful beginning has been made in Partábgarh to bring *usar* under cultivation by these means. A piece of good *usar* was chosen, which was thoroughly broken, in this instance with a steam plough belonging to the estate; *san* hemp (**Crotalaria juncea,** *Linn.*) was sown early in the rains, and the crop which was moderately good, ploughed in; barley was then sown, and gave a very respectable crop. It is, I believe, intended to repeat the process this year, after which it is hoped that the land will be fit for letting to cultivators. Even after one year's treatment cultivators offer from R4 to R5 per acre for the land.

Rice is reported to serve the purpose.

Experiment at Partabgarh.

San hemp, and barley sown.

This process may be provisionally recommended for trial, the tillage being the best that bullocks or labourers can effect, and the crop used being *san* hemp or rice, according to the wetness of the soil. The former is preferable where it will grow, as its cost of cultivation is nominal and its results appear good. Experiments to determine the relative value of different crops for ploughing in are at present in progress.

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RECLAMATION EXPERIMENTS MADE UNDER GOVERNMENT. Special manures. Artificial manures not suited but tried at Awa.

Special manures.—Before leaving the general subject of cultivation, mention may be made of results obtained with special manures. In the early years of the experiments some hopes were based on chemical or artificial manures, but the use of these has been abandoned since it has been realized that the sterility of the soil was due not to defect of any particular plant food but to badness of texture and to the presence of noxious substances. Thus at Awa a complete series of experiments was carried out with artificial manures; but the results were poor, and stable manure or indigo refuse (*i.e.*, bulky manures) were found decidedly more effective than the chemical fertilizers. *Departmental Report for 1880-81, paragraph 18, Appendix D.*

Gypsum.

The use of gypsum (*Calcium sulphate*) stands on a different footing, as it has been proved that the application of this substance changes the sodium carbonate into the much less injurious sulphate, and it is one of the commonest methods of reclamation in America. *Gypsum* was tried about 1885 with a certain amount of success, but not persevered with. A fresh experiment was started at Gursikran in 1896 on the recommendation of the Agricultural Chemist; the results were inconclusive, and the cost of gypsum landed in the *usar* tracts of these Provinces was found to be so great that the treatment cannot be recommended to agriculturists. *Departmental Report for 1886-87, paragraph 13.*

Chemical action beneficial but cost too great.

In the experiments in question the gypsum was supplied free of royalty by the Forest Department, but freight, carting, and expenses of applying came to R27 per ton when landed at Gursikran; of this sum, at least R20 would have to be paid by the cultivator, who would also have the royalty to pay. Now, if we assume that R60 is the largest amount which on the average can be profitably spent in reclaiming an acre, the maximum application of gypsum is only 3 tons. According to calculations made by Dr. Leather in the course of the experiment, one ton of gypsum of 85 per cent. purity will neutralise 0·52 ton of carbonate; therefore it will not pay to neutralise more than 1·56 tons of carbonate to the acre. But the first two feet of soil weigh about 8,000,000 lbs., or nearly 3,600 tons: 1·56 tons is 0·043 per cent. of this. It would therefore be practical to neutralise carbonate only to the extent of 0·043 per cent.; that is, it might pay where the total carbonate present was 0·2 per cent. or under, but the application would be useless where the proportion exceeded this. To make gypsum profitable for general use the cost of carriage must

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be greatly reduced; but as supplies have to be drawn from the hill districts, there is little probability of a substantial reduction, and the use of gypsum must remain financially unprofitable. The use of lime nitrate with the same object as gypsum was suggested many years ago by Brown, who described a simple method of preparing it in large quantities. I cannot, however, find that it was even tried in these provinces, but the experiment will be introduced.

Lime has been tried but result of trial not recorded.

Lime appears to have been tried many years ago, but no account of the results can be traced. Further trials of it are now being made at Juhi, where the amount of alkali is small.

CHAPTER VI.

Industrial Utilization of Usar.

INDUSTRIAL UTILIZATION OF USAR LAND.

The account given in the last chapter practically exhausts the work that has been done in the direction of utilizing the barren land for the production of ordinary crops. Three other general methods of utilization require notice—(1) the introduction of manufactures, (2) the production of supplies of fodder, and (3) the growth of trees valuable for fuel or otherwise. These methods will be noticed in this and the two following chapters.

Trade in crude carbonate of soda.

The extraction from alkali land of crude carbonate of soda for industrial purposes is a very common practice; the alkali is scraped off the ground and the salts dissolved out from the soil and recovered by evaporation. The industry is however organised on a very small scale and the products are inferior.

Glass industries exist where usar lands are found.

An attempt was made during the Awa experiments to establish glass manufacture on the lands infected with alkali. As a matter of fact, wherever alkali is abundant glass industries are to be found; but they are mostly very small, and it is only in parts of the Agra division where they can be called important. The principal products are the common glass bracelets which are usually worn, and of which there is a considerable export from some of the stations in the Etáwah district.

Glass-making cannot pay owing to competition with remanufacture of old glass.

In 1878 specimens of glass made from alkali were sent to London for analysis, and were reported to be perfect in composition, except for a slight deficiency of lime, which could easily be made good. A bottle factory was started, and good bottles were made; but it was found that they could not compete in price with the wares of the "bottlewala," who, as is well known, is able to buy up empty

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bottles for a nominal price. In fact the supply of empty bottles appears to be ample for the somewhat limited market in these Provinces. *Departmental Report for 1878-79, paragraph 57.*

Bottle-making having proved a commercial failure, the next attempt made was to introduce the manufacture of beads, which are imported in large quantities. After some preliminary experiments, Mr. Wilson visited Venice in 1880 and obtained a complete set of tools. *Departmental Report for 1880-81, paragraph 28.* As the result of his experiments, the following conclusions were arrived at:—

(1) The impurity of the alkali prevents the manufacture of good colourless glass, such as would be suitable for window glass.

(2) With proper skilled supervision glass can be produced of a quality much superior to the ordinary native manufacture, and probably cheaper.

(3) Good beads can be made, but it is doubtful whether they can be made at a cost lower than that of the imported articles. *Departmental Report for 1881-82, paragraph 37.*

No development of bead-making industry followed demonstration its possibility.

After two years' further experiments the final conclusion arrived at was that any improvement in manufacture must depend on the work being done on a large scale with skilled supervision. The enquiry then closed, and it was left to the commercial classes to take up the manufacture if they saw profit in it. No development of the industry has followed. *Departmental Report for 1883-84, Appendix I.*

Enquiries have recently been made by a leading firm in the English chemical trade regarding the deposits of soda in these Provinces, and early in 1900 a representative of the firm was supplied with all the information that was available and was shown some of the larger alkali plains. It is not yet known whether his enquiries will lead to any results.

Brick-making.

No enquiries appear to have been made as to the suitability of the clay (at least in tracts not strongly infected with alkali) for the manufacture of earthenware. I hope to take up this subject shortly, though it seems doubtful whether an extensive market could be obtained. Mr. C. G. Palmer, C.I.E., informs me that bricks made from *usari* soil are extraordinarily hard if burnt enough to fuse the salts into a glass which permeates the whole substance of the brick.

In the year 1882 Major Pilcher, *the Assistant Director of the Oudh Agricultural Department*, suggested to the managers of various

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Paper Mills that English caustic soda could be replaced by the use of soda prepared from alkaline earth. The distance and consequent heavy freight prevented the use of the country material in Calcutta and Bombay, but the *Lucknow Paper Mills* adopted the suggestion and have made their own soda for the last twenty years with most satisfactory results. The supply within a reasonable distance of the mills is however limited.

Soda for paper making.

CHAPTER VII.

The Production of Fodder on Usar.

PRODUCTION OF FODDER.

One main object of the enquiry has from the outset been to discover some means of utilizing the barren land for supplementing the insufficient supply of fodder. A leading feature has been the study of the grasses which grow or can be produced on barren land—a study which has all along been in the hands of Mr. J. F. Duthie, F.L.S., *Director of the Botanical Department of Northern India*. From the outset it was found that enclosure was essential for the proper growth of grass. The close grazing which is universal in these Provinces, and which must be expected to continue so long as land is left unenclosed, is fatal to the proper growth or extension of herbage, the young shoots of grass being nipped off and the tender roots destroyed by the hoofs of the animals.

Close-grazing is fatal to the full utilisation of usar land.

In an appendix to the report for 1881-82, *Departmental Report for 1881-82, Appendix II, paragraph 15*, Mr. Wilson mentioned the following grasses as being found on the *usar* at Awa:—

Grasses on usar land at Awa.

(*a*) *Khar usara* (**Sporobolus arabicus**, *Boiss.*), the usual grass which develops greatly as an immediate result of enclosure.

(*b*) *Bhurburui* (**Sporobolus coromandelianus**, *Link*), which comes up in the rains but dies away quickly and gives little fodder.

(*c*) *Dab* (**Eragrostis cynosuroides**, *Beauv.*), which appears on rather better patches, and is of some use for thatching but of little value for fodder.

(*d*) The well-known *dúb* (**Cynodon Dactylon**, *Pers.*), which is found in depressions where the water lodges, and spreads when the land is flooded with canal water.

Observation of the plots under operations at Awa showed that the result of enclosure was that land previously bare became covered

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with a crop of **Sporobolus arabicus**, and that the better grasses showed a tendency to spread when protected from grazing. Thus in 1881 and 1882 cuttings from selected patches yielded from one to one-and-a-half ton of hay per acre; but a note on record in my office shows that this did not represent the average outturn of the plots, as there were at that time numerous bare spaces, none of which were included in the plots from which cuttings were made.

PRODUCTION OF FODDER. Better Grasses spread when protected from grazing.

As the result of these observations, hopes were entertained that by the mere process of enclosing *usar* and planting trees on the better portions efficient reserves for the supply of fodder and fuel could be provided at a profit, or at least without serious direct loss. Large schemes were formulated dealing with as much as 100,000 acres but eventually four plots were taken up for further experiment. The plots were as follows:—

Name of reserve.	Situation.	Area.	Date of acquisition.
		Acres.	
Juhi . . .	5 miles from Cawnpore	102	July 1882.
Amramau . .	4 " " "	54	Ditto.
Gursikran . .	7 " " Aligarh	718	August 1885.
Cherat . . .	5 " " "	242	Ditto.

The original intention was that these plots should be maintained as fuel and fodder reserves; but as has been mentioned in the last chapter the object of the experiment was in part altered, and the greater part of Amramau and Cherat and a protion of Gursikran were brought under the plough, the remainder of Gursikran and the whole of Juhi (except a few small plots) being reserved for the original object of the experiment.

Juhi experiment in protecting grasses from excessive grazing.

The history of the Juhi enclosure is briefly as follows:—

In 1890 after eight years' enclosure, the results were considered disappointing. *Departmental Report for 1889-90, paragraph 6.* "Enclosure has unquestionably induced a vigorous growth of grass, and the grasses are slowly improving in quality. But the staple grass is still the common *usar* grass (**Sporobolus arabicus**) which dies down after the rains, and which, though largely eaten by animals, is not nourishing." In the following year the verdict, *Departmental Report for 1890-91, paragraph 5*, was: "The fact is now conclusively established that the typical grasses cannot be counted on for nutritious fodder, and are coincident and conterminous with the rains ...... It is probable that as the quality of the soil improves through enclosure, the character of the grasses will gradually improve; but the

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process, even helped by artificial sowing, must necessarily be slow. In the last rains most of the grasses on the Juhi *usar* were made into hay as an experiment. It has not yet been sold, as the cavalry have refused it for their horses ...... The rest of the grass was sold standing at R2-8-0 the acre, and was cut and consumed in a green state."

In 1892 the following notes were recorded :—

"The typical *usar* grass (Sporobolus arabicus) and another species (Chloris virgata, *Sw.*) still grow abundantly: the former makes poor hay, but the latter is more nutritious. Several good fodder grasses have also obtained a footing, and some patches of land which up to 1888 had thick deposits of *reh* on them are now covered with more or less valuable grasses. *Dúb* grass (Cynodon Dactylon) is by no means uncommon ...... Nine different kinds of grass seed, specially suited to *usar* land, were sown, but only one (Panicum javanicum, *Poir. Syn.* P. Helopus, *Trin.*) succeeded well." *Departmental Report for 1891-92, paragraph 5.*

Later notices are generally to the same effect. *Departmental Report for 1894-95, paragraph 15.* The herbage was increasing and better grass apparent; but the quality of the hay continued poor and it was generally refused by the officers of the Commissariat Department as being unsuitable for fodder. Some portion of the grass could always be sold standing, as is natural so close to the great Cawnpore market, but hay-making was gradually restricted. In 1896 we learned the important fact that the grasses on the reserve would not stand a drought, and the herbage did not entirely recover in 1897, when the outturn of hay was only 16 maunds per acre. Next year the season was very favourable, and the outturn was about 40 maunds— a figure which was again reached in 1898. *Departmental Report for 1896-97.*

The process by which better grasses replace poor ones is very slow.

The history of this reserve seems to show that if barren land, not on the whole seriously infected with alkali,* is enclosed and kept free from grazing, the natural grasses will grow more or less luxuriantly, and better grasses will establish themselves in places; but the process

* As in the other reserves the soil was not analysed before the experiments were begun. In order to get an idea of the original condition of the land, I took samples from patches of barren land just outside the fence of the enclosure. The total of soluble salts in the first 6 inches of soil of these patches varied from 0·2 to 0·4 per cent., most of which was carbonate. The samples were taken from bare soil at a period when evaporation had been very active; and, therefore, it is probable that the salts were largely accumulated near the surface, and that these plots could be cultivated with success if the salts were kept down. The inference is that the main enclosure was never seriously affected with alkali, except in particular patches.

Upland Barren Lands (Usar). (*W. H. Moreland.*) | **REH.**

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is very slow. Juhi has been enclosed for 20 years, and the original inferior grasses are still predominant, so that the hay is of bad quality.

Gursikran experiment in protecting grasses from excessive grazing.

The Gursikran enclosure differs from Juhi in having been much more affected with alkali. There is unfortunately no record of the actual quantity of alkali in the surface soil, but there is no doubt that the portion reserved for grass was originally covered in many places with an alkali encrustation. In 1888 Mr. Duthie, the Botanist, wrote: "The prevailing grass is *khar usara*, which over large portions of the ground grows in great luxuriance, unmixed with any other kind of vegetation. Some of the blocks are almost entirely bare and efflorescent; others contain nothing but *usar* grass; whilst in others there is a mixed vegetation, including various sized patches of *dúb* grass which appear to be rapidly spreading." *Departmental Report for 1890-91, paragraph 8.* In 1891 it was noted that "the *usar* grass grows very luxuriantly; but there is little demand for it in the green state, and it makes very inferior hay . . The grass was condemned as unsuitable for horses." *Departmental Report for 1893-94, paragraph 16.* In the following year "continued improvement" was noticed; and in 1894 the fact was recorded that while the *usar* grass (**Sporobolus arabicus**) still prevailed, *bát* (**Diplachne fusca**, *Beauv.*) was rapidly spreading, and *dúb* (**Cynodon Dactylon**) and *janewa* (**Andropogon annulatus**, *Forsk.*) had got the upper hand in places where the water lies. The outturn of hay however was very poor, being only $7\frac{1}{2}$ maunds per acre. *Departmental Report for 1894-95, paragraph 17.* A year later the outturn was 13 maunds of hay per acre, but the hay was a failure as fodder. "Cattle do not eat it with relish, and experiments made by the *Assistant Director* show that they prefer even rice straw to the *usar* hay." *Departmental Report for 1895-96, paragraph 17.* In the following year the rainfall was deficient, and the yield of hay varied from $8\frac{1}{2}$ to 12 maunds per acre. In this year some of the land was used for grazing and showed rapid deterioration—a fact which proves that temporary enclosure is of no permanent use as far as the provision of pasture is concerned.

Slow improvement.

In 1897, with more favourable rainfall, the yield of hay rose to 15 maunds, but the hay was still condemned as innutritious. *Departmental Report for 1896-97, paragraph 30.* In the following year the yield of hay fell to about 10 maunds. Various grasses obtained from New South Wales were tried in this year, but all failed to grow. *Departmental Report for 1897-98, paragraph 28.*

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PRODUCTION OF FODDER. Similar experience at Cherat.

Experience at Cherat, also an alkali reserve, was generally similar to that at Gursikran; but the observations covered a shorter period, as the reserve has passed into private hands.

Slow work: twenty years have been necessary for a slight improvement of fodder and if free grazing is permitted land will revert.

As a result of from 15 to 20 years' work on these reserves, it may be taken as established that by enclosure and prevention of grazing bare alkali land will become covered with grasses, and that in time the better grasses will make way. The yield is however poor in quantity and bad in quality, and even after 20 years we can only count on half a ton of innutritious hay to the acre. It is also established that if after a period of enclosure free grazing is permitted, the land will very rapidly revert to its original state; in other words, it is impossible by this method to turn barren land into pasture.

Better hay might be made by cutting in time.

I am not entirely satisfied that the hay hitherto produced has been as good as possible. The dates of hay-making in the early years of the experiments are not on record; but of late years the grass has generally been allowed to stand too late, and has not been cut until the woody parts have made excessive development: experiments are now in progress with the object of ascertaining whether earlier hay-making will give a more nutritious crop. As was remarked by Dr. Voelcker, it is difficult to get good hay-making weather at the time when the grass is ready for cutting; but bright days occur, and the sun is so hot that the hay can be made in a day.

Ensilage has been made but with disappointing results.

There is usually in populous places a market for the green grass; but the supply of fodder in this case comes just when the market is fullest, and is not available to supplement the fodder supply at the season when it is seriously defective. Consequently when it was seen that the hay was defective, attention was turned to ensilage in the hope that more nutritious feed might be obtained by this process. Ensilage has been made for the past ten years, but for the most part with disappointing results. Thus in 1893-94 the ensilage made from grass was found unfit for use; in 1894-95 it was found "of some use during the cold weather;" and in 1895-96 it was reported to be "generally of poor quantity." Better results were obtained by mixing the grass with chopped fodder, such as *guar* (Cyamopsis psoraloides, *DC.*) *impi* or *juar* (Andropogon Sorghum, *Brot.*); but it is very doubtful whether this method would be practised by cultivators, who would probably prefer to keep their good fodder separate. The construction of proper silos is out of the question owing to the capital outlay required, and stacking or storing

Cost of constructing proper silos prevents the making of the best ensilage.

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in pits involves a good deal of waste, which does not occur when the dry fodder is stored in the ordinary way.

Trial of salt-bushes.

In connection with the question of fodder supply, much interest attaches to the attempts to introduce Australian salt-bushes. *Departmental Report for 1881-82, paragraph 30.* The first trial of these appears to have been made in 1882, when some varieties were tried, one of which (**Atriplex nummularia**, *Lindl.*) promised to do well.

In 1883-84 the following notes are on record :—

The plants of **Atriplex** and **Chenopodium**, received from Sahάranpur, are also thriving. *Departmental Report for 1883-84, Appendix I, paragraph 13.* The **Atriplex** received in 1882 has flowered but produced no seed.

"A species of **Chenopodium** has produced seed which has been sown ; and some young plants thus obtained have recently been planted out. Some seeds of **Atriplex nummularia**, *Lindl.*, and allied species have recently been received from Sahάranpur and sown in the nursery."

Salt-bushes are killed by the rains.

Unfortunately the further detailed history of these plants is not on record, but all have disappeared. I learn however from Mr. Duthie that the failure of these plants was observed to be due to their inability to live through the wet season when, as already remarked, the surface of the *usar* is slimy mud, and water often stands on it. Salt-bushes thrive best with a light rainfall and on dry soils, and are therefore more likely to succeed on the broken raviny lands where the surface drainage is efficient. Some species which have not yet been tried have however been procured, and these will be planted to see if they can survive the adverse conditions which were fatal to **Atriplex nummularia**. It is also intended to try along with these certain allied plants which are to be found growing in other parts of this country.

CHAPTER VIII.

Tree-planting on Usar.

TREE-PLANTING ON USAR LAND.

Trial of Acacia arabica.

The first attempt on record* to establish a regular plantation on barren land was started in 1874 at Pardilnagar in the Aligarh district, the work being taken up by the Irrigation Department. An area of 10 acres alongside the Sikandra Rao distributary was prepared in seed beds dug three feet deep and filled with good soil or silt to a

* Attempts were made as early as 1868 to plant up *usar* in Oudh, but were discontinued before any results had been obtained.

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level above that of the surrounding land. *Babuls* (Acacia arabica, *Willd.*) were sown, and various other trees planted, and coarse grasses (the kinds are not specified) planted between the trees. The plantation was flooded twice a month for the first year, after which it was not irrigated.

Trial of Dalbergia Sissoo.

The plantation cost about R50 the acre, and the results were promising up to 1880, when the Conservator of Forests reported that about four-fifths of the land was stocked with healthy *babuls* from 10 to 20 feet high with an occasional *sissoo* (Dalbergia Sissoo, *Roxb.*), and that there was a luxuriant growth of grass, while very little alkali was visible. Later reports were however of a different tone. In 1882 the Conservator reported that the trees had not grown much; and by 1886 all the larger trees were gradually dying away, while the younger still looked healthy. In 1888 (the trees being 14 years old and six inches to nine inches in diameter) it was reported that the trees were dying off rapidly.

Both dying after 14 years.

Failure of attempt to grow Tamarix.

Mr. C. G. Palmer, C.I.E., has supplied me with the following note regarding another early experiment:—

"There was a patch of middling bad *usar*, made much worse by percolation lying in the fork between the Agra canal and the Agra navigation canal. All manner of things were tried on it without any success: among other plants the *farash* (Tamarix articulata, *Vahl*) was tried and proved a failure. Finally the ordinary small *jhau* (from recollection I should say it was Tamarix dioica, *Roxb.*, but I took no notes at the time) got a start there and very soon covered the whole area with a dense growth of shrub. Before this had been in force very long we had to cut it down and sell it because the dense growth harboured great numbers of pigs. The *jhau* sold at a profit as fire-wood. *Jhau* sends down its roots to a considerable depth, and it is possible that its success in this particular case is due to the clay layer being thin and having been penetrated by the roots. But I think the plant worth trying on swampy *usar*, where the surface can be washed by any form of flooding."

Acacia arabica, Prosopis spicigera and Melia Azadirachta planted at Awa.

The next systematic attempt to grow trees on barren land was made under Mr. Wilson in Awa and elsewhere. *Departmental Report for 1880-81, Appendix D.* Five methods were adopted which are described as follows:—

(i) Holes were dug three feet deep, three feet wide at top and two feet wide at bottom, and then refilled with the soil taken out. Good soil was added to some of the beds.

(ii) Holes were dug of the same size as (i), and the soil was inverted, the earth excavated from one hole being

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thrown into the next. Good soil was added to some of the beds.

(iii) Holes were dug two feet wide and two feet deep and the soil inverted.

Methods of planting.

(iv) Channels were dug one foot deep by one foot six inches broad at the top and nine inches broad at the bottom, and the soil made into a ridge at one side. Seeds were sown on the ridge.

(v) The ground was ploughed and then prepared in ridges six inches high and furrowed six inches deep, the ridges being 10 feet apart.

In the first and second methods good soil was added to raise the seed beds above the level of the *usar* : at first it was added to half the seed beds, but eventually it was added to the remainder, as without it germination was very bad. The seeds sown were *babul* or *kikar* (**Acacia arabica**, *Willd.*), *chaunkar* (**Prosopis spicigera**, *Linn.*), and *nim* (**Melia Azadirachta**, *Linn.*) ;* of these, *babul* did best.

Complete failure when no good soil was added.

The methods numbered (iii), (iv), and (v) were complete failures. By the first method the seeds came up in 5 per cent. and by the second method in 15 per cent. of the beds, but they were weakly and were killed off by drought.

In the following year the ridge system was abandoned, and the holes were dug three feet deep, the soil being inverted. *Departmental Report for 1881-82, Appendix II.* A layer of good soil, three inches to 6 inches thick, was put on all the beds. Sowings were effected in June after the first rain and the seeds germinated well, but floods in July destroyed the young plants. Re-sowings were carried out by the middle of August, but most were killed in September and October. After this the beds were filled with *babul* which had been raised in nurseries.

Some success with Acacia arabica when good soil was added.

As regards the trees tried, *babul* did best. *Nim* (**Melia Azadirachta**, *Linn.*) and *shisham* (**Dalbergia Sissoo**, *Roxb.*) made a good start, but died off in the hot weather. *Chaunkar* (**Prosopis spicigera**, *Linn.*) did not germinate freely, and on the whole *babul* was preferred.

In 1882 transplanting of *babul* was continued, and the conclusion was drawn that the tree will thrive only in the better kinds of *usar*, and

* Formerly termed **Melia indica.**

TREE-PLANTING ON USAR LAND.

after 1883 little extension was carried out. *Departmental Report for 1882-83, Appendix I.* The plantations then passed with the rest of the estate into the hands of the landowner, and detailed records of their progress are wanting; but the following particulars have been ascertained at a recent inspection.

The land planted by the methods iii to v (described above) is practically bare of trees, except for a few miserable *babuls* or *mahuá* (**Bassia latifolia**, *Roxb.*) of no value whatever. In the rest of this plantation (known on the estate as "*baghia*") the trees were planted in holes: here the number of trees now in existence is rather greater, but they are not yet of the size for felling and are dying off. The value of the timber standing on the whole of this plantation ($10\frac{2}{3}$ acres) is about R25, to which about R5 may be added for trees which have fallen. There is nothing in the way of grazing: most of the land was quite bare. This, the original plantation, was therefore a failure.

Tree-planting succeeded on slightly alkaline land.

The next plantation (known as "*khadar*") covered two different kinds of soil. One was a moderate clay, quite workable and not apparently alkaline. On this portion the plantation is very fair, though the trees have suffered from overcrowding. The other kind of soil was typical *usar* with a good deal of carbonate: on this the plantation has entirely failed, and the land is at present worthless for grazing or anything else.

The plantations in Janauli near Awa, which were made about the same time, have been more successful. The soil is certainly *usar*, and there is a very fair stand of trees, but there are no signs of reproduction (although the plantation is not used for grazing). Apparently in this plantation the holes were dug three feet deep: now examination of the soil shows that the layer of clay is comparatively thin (not more than three feet deep at the spot where I tested it). The holes were therefore dug deep enough to give the roots access to the porous sub-soil, and to this must be attributed the partial success of the plantation. The absence of reproduction must be due to the fact that the seedlings, not having access to the porous layer, are unable to grow in the impervious clay; and this indicates the great difficulty of making such plantations remunerative, as they would have to be replanted periodically.

On the other reserves all kinds of trees were constantly being planted in various ways, but up to 1895 very little success had been

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TREE-PLANTING ON USAR LAND.

obtained. As a rule, when the season was favourable, the young trees looked promising for a few years; but the great majority rapidly died out, and a casual inspection of the older trees at Juhi and Gursikran shows that nothing like a regular plantation has been formed, and that a regular supply of fuel or of any economic product has not been obtained. The following conclusions may be definitely drawn from the experiments of the last twenty years :—

CONCLUSIONS WITH REGARD TO TREE-PLANTING.

(1) No method of sowing seeds on tilled *usar* land can yield a profitable growth of wood.
(2) Sowing on ridges is equally unsuccessful.
(3) Planting out young trees is a failure wherever the hole in which they are planted is underlaid by a layer of nodular limestone or by a compact stratum of very hard clay.

In all these cases the main cause of failure is identical. If the seed is able to germinate or the young plant to start growth, things go well until the roots have passed through the tilled soil or the earth filled into the hole; but when the roots strike the hard clay they are unable as a rule to penetrate the compact mass, which is practically impermeable to air and water. The necessary conditions of root development being thus absent the tree dies, the exceptions being apparently due to the roots having found cracks or fissures in the hard subsoil through which they have penetrated to the more congenial soil below.

'Thala' system of planting, alkali-free earth being added.

Deep thálá system.—Considerations of this nature led to the adoption about 1895 of the method of planting which has come to be known as the deep *thálá* system. As originally introduced, this system required that the holes should be from three feet to four feet deep, and should be filled in with earth free from alkali and mixed with manure: the surface should be raised about a foot above the level of the plain, and healthy seedlings planted out and carefully tended and watered for the first year. Later experience goes to show that no limit should be prescribed for the depth of the holes: this must be determined by an examination of the subsoil, and the holes must be dug through the heavy clay, so that the root can penetrate to the coarser material lying below, which is to some extent permeable by air and water.

No limit should be prescribed for depth of holes.

The following statement shows the present results of planting done on this system in the years from 1895 to 1898. The observa-

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REPORT ON TREES PLANTED UNDER THALA SYSTEM ON USAR LAND.

tions were made in the cold weather of 1900-1901, when the existing trees were classed as "flourishing" or "struggling":—

Tree.	Season of planting.	Number planted.	Results.			Remarks.
			Flourishing.	Struggling.	Dead.	
I.—Gursikran reserve.—Alkali land						
Babul (Acacia arabica, *Willd.*).	1897	160	20	86	54	Inferior soil used for filling *thálás.*
	1898	138	112	10	16	
Shisham (Dalbergia Sissoo, *Roxb.*).	1895	20	13	1	6	
	1897	65	...	...	65	Ditto ditto
	1898	40	...	10	30	
Nim (Melia Azadirachta, *Linn.*).	1897	150	23	70	57	Ditto ditto
	1898	111	90	6	15	
Guava (Psidium Guajava, *Linn.*).	1896	36	15	5	16	
	1897	26	1	...	25	
Farásh (Tamarix articulata, *Vahl*).	1898	15	15	...	...	
Ber (Zizyphus Jujuba, *Lamk.*) . .	1897	25	4	...	21	
Mahuá (Bassia latifolia, *Roxb.*) . .	1898	15	1	1	13	
II.—Juhi reserve.—Land not strongly alkali.						
Mango (Mangifera indica, *Linn.*).	1895	17	...	...	17	
	1897	28	7	2	19	
Guava (Psidium Guajava, *Linn.*).	1895	43	6	11	26	
	1896	27	...	12	15	
Jamun (Eugenia Jambolana, *Lamk.*).	1897	8	8	...	...	
	1898	20	...	...	20	
Babul (Acacia arabica, *Willd.*).	1897	15	14	1	...	
	1898	60	45	11	4	
Dhak (Butea frondosa).	1897	21	13	2	6	
	1898	40	21	4	15	
Nim (Melia Azadirachta, *Linn.*) .	1897	15	13	...	2	
Shisham (Dalbergia Sissoo, *Roxb.*) .	1897	15	12	...	3	
Ber (Zizyphus Jujuba, *Lamk.*) .	1897	15	11	4	...	
Mahuá (Bassia latifolia, *Roxb.*) . .	1897	20	...	...	20	
Eucalyptus sp. .	1898	20	4	...	16	

The bad results obtained in 1897 at Gursikran were apparently due to the system tried in that year of refilling the *thálás* with the

TREES WHICH MAY BE GROWN UNDER THE THALA SYSTEM.

earth dug out of them for 2½ feet out of a total depth of four feet. Had this succeeded it would have reduced the cost of the system, but as a matter of fact it was a failure. Leaving these results out of account, it may be said that on distinctly alkaline land *shishams* and guavas were not a success, but that *babul*, *nim*, and *farash* gave results of promise. *Nim* and *farash* could not pay in practice, but *babul* might. On the Juhi land (not particularly alkaline) mangos, guavas, *jamuns*, and a species of eucalyptus were failures. *Dhak* did moderately, and *babul*, *nim*, *shisham* and *ber* were successful. Of this list only *babul* and *ber* can be expected to pay. The entire loss of the *mahuás* planted in 1897 was due mainly to unskilful treatment; the seedlings planted in 1899 were better cared for, and their present condition is as follows:—

	Number.
Planted	160
Flourishing	82
Struggling	23
Dead	55

These figures are sufficiently encouraging to justify perseverance in the attempt to grow this most valuable tree on such soils.

These trials gave such favourable results at the outset that in 1898 a new reserve was taken up at Abbaspur, near Unao, to be used for the propagation of *babul*, the growth of which is of special importance, as the Cawnpore tanneries have for the present almost exhausted the supply of bark in the neighbouring districts. No opinion can yet be given as to the ultimate success of this plantation, but at present the progress made is not discouraging.

It may appear premature to discuss the future application of a method the success of which has not been established, but the following observations may be put on record:—

(*a*) The method is substantially the same as was adopted in the successful plantation at Janauli which is described above, where the holes were dug to a depth sufficient to give the plants access to permeable soil.

(*b*) The method will not apparently ensure a reproduction of the plantation. The seedlings may be expected to die off when they strike the hard pan, while there will hardly be room for fresh seedlings to grow in the original holes.

(*c*) It follows that other things being equal, the most desirable course is to grow trees which will yield a recurring income for

TREES WHICH MAY BE GROWN UNDER THE THALA SYSTEM.

as long a period as possible rather than those from which the income depends on a short rotation. Of all trees that the small landowner or tenant could raise, *mahuá* (Bassia latifolia, *Roxb.*) appears the most desirable in this respect if it can be made to grow.

(*d*) This does not however condemn the attempt to raise *babuls* if one course of the rotation will yield a profit. The cost of planting an acre with 150 trees and maintaining them till established is under R120, with all the disadvantages (already enumerated) which result from Government supervision. Persons working for their own interest could probably effect considerable savings. A fair yield of *babuls* should bring in R200 to the acre when the crop is ready, so that there are not unreasonable hopes that with a continuance of the demand for bark, successful plantations on this system may be financially profitable where facilities for carriage exist. If so, they will incidentally confer great benefits on the locality where they may be established, by supplying timber particularly suitable for agricultural needs, and by affording a plentiful supply of fuel.

(*e*) It does not appear that fuel reserves on a self-supporting basis can be established on this system of planting, except possibly in the immediate vicinity of large towns, or else with trees which yield some other valuable product in addition to the fuel.

Experiments have been made from time to time with a large number of trees or shrubs having special qualities. The following may be mentioned :—

Jait (Sesbania ægyptiaca, *Poir.*).—This plant is apparently of no economic value, but was recommended for use in clothing the ground and so preparing it for cultivation. It was found however that though the plant would flourish in soil that had been enclosed and was already covered with vegetation, it would not grow in really alkali soil. It does not therefore serve any useful purpose.

Jhau (Tamarix gallica, *Linn.*).—This plant, well known in the Ganges valley, is of considerable use for thatching, etc. It has grown fairly when planted in Gursikran, but does not yield a heavy enough crop to be commercially profitable.

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TREES WHICH MAY BE GROWN UNDER THE THALA SYSTEM.

Farásh (**Tamarix articulata**, *Vahl*).—This has been tried for many years, but has generally failed. It is now growing at Gursikran under the deep *thálá* system, as shown in the foregoing statement.

Date Palms (**Phœnix dactylifera**, *Linn.*).—These were started some time before 1890 at Juhi, Cherat, and Gursikran. Some of them survived; but the progress was very slow, and no crop of fruit has yet been obtained at Juhi or Gursikran. At Cherat the trees are doing well; 132 are in existence of which 72 have fruited: these however appear to have been planted on better patches of land.

Tanning trees.—Four species, **Terminalia belerica**, *Roxb.*, **Terminalia Chebula**, *Retz.*, **Phyllanthus Emblica**, *Linn.*, and **Zizyphus Xylopyrus**, *Willd.*, were planted at Juhi in 1893: the first and third are flourishing; the others are struggling.

Agave americana, *Linn.*, a fibre plant, was planted as a fence in Juhi in 1893 and subsequent years. It has survived: but the growth is very slow, and there is not as yet anything worth cutting, even on the earliest planting.

Pithecolobium dulce, *Benth.*, which is more familiar to the public under its now discarded name **Inga dulcis**, *Willd.*, was sown at Juhi in 1896, but failed to germinate.

CHAPTER IX.

Summary.

SUMMARY.

The methods of treating *usar*, which have given results of positive value, may be summarized as follows. Where manure is available *usar* that is not strongly polluted by alkali may be cultivated. The financial results will depend mainly on the use that could be made of the manure in other ways. A special case is the system of trenching nightsoil in the neighbourhood of towns: in this case the manure is readily available in sufficient quantities to produce excellent results.

Where manure is not available, the better kinds of *usar* can probably be cultivated by altering their texture by the addition of organic matter, the most satisfactory method being the ploughing in of any crop that can be made to grow during the rains. Where the water lodges at such seasons it will probably be found necessary to grow coarse rice for this purpose, while where drier crops will

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SUMMARY.

have a chance *san* hemp (**Crotalaria juncea,** *Linn.*) *mandua* (**Eleusine coracana,** *Gaertn.*) or *sawan* (**Panicum colonum,** *Linn.*, Syn. **P. frumentaceum,** *Roxb.*) may succeed. The best crops for this purpose have however still to be determined. Where ample means of irrigation exist the growth of *bát* grass (**Diplachne fusca,** *Beauv.*) may be found a useful preliminary operation.

The method of silting has been shown to be a success where local conditions will permit of its adoption, but it is not applicable to any large portion of the land under consideration.

The alkali of the worst kind of *usar* has been proved suitable for use in making glass, provided the enterprise be on a large scale and under skilled supervision: and it has been used with success for preparing caustic soda for industrial purposes.

The following may be classed as negative results or failures: use of artificial manures, use of gypsum (on financial grounds), enclosure for fodder, propagation of grasses, ordinary methods of planting timber, sowing seeds of timber trees broadcast, and surface drainage.

The deep *thálá* method of planting trees is on its trial, and no opinion can be pronounced on it until the young trees now in the ground either die off or come to maturity. The enquiries which have still to be made will deal with the following points:—

(1) The removal of the alkali from the worse *usars*, so as to bring them within the range of the methods of cultivation which are successful on the better classes of land. At present the methods which deserve a trial are the different systems of subsoil drainage and the scraping of the surface at a time when the efflorescence is at its maximum.

(2) The use of lime on land not badly affected with alkali.

(3) The use of nitrate of lime on alkaline land.

(4) The growth of indigenous and imported alkali plants together with a determination of the various plants that grow on unenclosed *usars*.

(5) Determination of the best crops for ploughing in, in order to improve the texture of the soil.

(6) Suitability of the clays for pottery manufacture.

Enquiries in these directions are either in progress or will be started as opportunity offers.

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G. I. C. P. O.—No. 506 R. & A. D.—28-12-01—2,230.—G.M.S.

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(Vegetable Product Series, No. 69.)

THE

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ACACIA spp.

[*Dictionary of Economic Products, Vol. I.*, **A. 100.**]

The INDIAN ACACIAS.

By GEORGE WATT, M.B., C.M., F.L.S., C.I.E.

A review of available information written mainly with the object of bringing out the chief commercial facts regarding The Indian Acacias.

INTRODUCTORY.

The genus Acacia is a genus of spinose or prickly climbing shrubs or trees which belongs to the Natural Order LEGUMINOSÆ, and constitutes the most characteristic group of plants in the Sub-order MIMOSEÆ. There are in all 430 species, of which two-thirds are peculiar to Australia. India possesses only some 20 and these are distributed throughout the plains, two ascending to altitudes close on 5,000 feet. The reader should consult Major D. Prain's paper on *Some Additional Leguminosæ (Journ. Asiatic Soc. Beng., Vol. LXVI, 1897, pages 506-511)*, for the most recent botanical opinion regarding the species of this genus. **Indian Acacias.**

It may, strictly speaking, be said that every Indian species is of economic value. Three are of Commercial Importance, *viz.*, *Acacia arabica, A. Catechu,* and *A. Senegal,* while the remainder may be regarded as of very much less value, in other words as of local interest mainly. The bushy and arborescent forms, as a rule, afford astringent barks, leaves or pods and are appreciated as MEDICINES, as TANS or as DYE AUXILIARIES. Many of them afford useful GUMS that are more or less soluble and edible. Interesting particulars regarding the fungi that appear to be instrumental in the formation of these gums will be found in a paper written by Mr. J. B. Prebble, and published in the *Pharmacographia Indica* (*Vol. I., pages 544-55*); see also Massee's *Plant Diseases, page 122.* The BARKS of some species yield coarse cordage FIBRES. The majority of the trees are **Commercial Species.** **Generic Properties.** **Gum.** **Fibre.**

INTRODUCTORY.

Structure of Wood.

of the greatest value to the inhabitants of the tracts where they are at all prevalent both as sources of TIMBER and FUEL. With regard to the timber Mr. Gamble observes that the Indian species have sharp prominent medullary rays, which are short in *A. Catechu, ferruginea* and *modesta,* but long in the others. As a rule they are not well marked in radial section, but *A. leucophlœa* and *arabica* are exceptional in this respect—the former being beautifully marked. All the species of *Acacia* are recognised as of the utmost importance in AGRICULTURE, as, for example, in the reclamation of waste lands, indeed, as a rule, they are the chief trees and shrubs met with in certain arid regions. And lastly either as living hedges or as dead thorny fences their spinose property is much appreciated for the protection of cultivated lands, and the leaves beaten from the twigs afford a much valued FODDER to the cattle of the regions in which they are plentiful.

Agriculture.

Hedges.

Fodder.

Acclimatised Forms.

A few foreign species have become completely acclimatised in India, such as *A. dealbata*—the *AUSTRALIAN SILVER WATTLE*—and *A. melanoxylon*—the *AUSTRALIAN BLACK-WOOD.* These are fairly general in the warm temperate tracts of India, more especially in the Nilgiri Hills where they were introduced in 1840.

It may perhaps suffice to deal very briefly with the so-called unimportant species under the present generic position and to touch mainly on their special features of interest, leaving the above observations to be more or less applicable to all of them.

ACACIA CONCINNA. Habitat.

ACACIA CONCINNA, *DC.; (Dict. Econ. Prod. I., 44).*—A common prickly scandent bush met with in the tropical jungles throughout India. Since the pods are extensively used as a detergent, they are often confused with the *SOAP NUT (Sapindus Mukorossi),* and indeed they bear, as a rule, the same vernacular names, *viz., rita* or *ritha.* In Bengal the present plant is distinguished as the *ban* (wild) *ritha* and amongst others the following names are given to it in the provinces :—*aila, rassaul, sika, shika, sikekai,* or *chikakai,* or *chikaya, gogu, sige* (the unripe pod being *kayi*), *ken-bwon* or *kin-bun, suboknwe.* In Sanskrit it is spoken of as *Saptala* or *charma-kasa* (skin-injurer) in allusion to its numerous thorns.

Tan.

The BARK of this bush is to some extent used as a TAN for fishing lines and is imported for this purpose into Bombay from Kanara. The chief interest in the plant proceeds, however, from the well-known DETERGENT property of the PODS. These have been extolled by every writer from the date when Ainslie and Roxburgh first made them known to the Western world. They are largely employed in washing silk and woollen goods, and it is believed some of the best tinctorial results are to be attained only with yarn washed by these

Soap Pod

pods, previous to being dyed. They may be used with much advantage in washing tarnished silver plate, the objects attaining a brilliancy, on being rubbed up with a little chalk, hardly to be secured otherwise.

TRADE. Washing Silver Plate.

The TRADE in these detergent pods must be very considerable in India as a whole. Collective returns are, however, not available, but we read of from 10 to 135 tons being imported into Bombay annually and mainly from South Kanara. *The Madras Mail* (*January 1898*) speaks of the local supply coming from Palghat and Vaniembaby, and urges an effort being made to place these pods on the European markets.

Trade.

A. FARNESIANA, *Willd.*; (*Dict. Econ. Prod. I., 48*).—A small tree indigenous to India and cosmopolitan in the tropics. It is best known in Europe as *CASSIE FLOWER* and curiously enough is in India usually denoted by comparative or descriptive names such as *vilayati* (English) *babul* or *kikar, pissi-babul, gu-kikar, gaud-babul, gaya-babul, gandhi-babul, gabur, tal-baval, baver, kne-bawal, oda-sale, murki-tumma, naga-tumma, piktinni, kasturi-tumma, kamputumma, jali, nanlongyaing, hanlogyaing*, etc. Dutt mentions *arimeda* and *vitkhadira* as the Sanskrit names of this tree and Elliott calls it the *arimedamu.*

A. FARNESIANA. Habitat.

It is largely cultivated in France on account of the rich PERFUME obtained from the FLOWERS. In fact although it yields a GUM and other products similar to most species, the chief interest in this tree centres in its *CASSIE FLOWERS.* Sir F. A. Abel, Bart., K.C.B., in a letter to the Government of India, dated the 16th July 1894, gives the following interesting particulars :—

Cassie Perfume.

"In a note on drugs Mr. Umney mentions incidentally and in very high terms CASSIE POMADE, made in India. This was prepared by Mr. . . of Naini Tal (recently deceased), who is believed to have been an engineer by profession, but who used to send to London supplies of CASSIE POMADE.

Indian Cassie Pomade.

"Mr. Umney makes the following remarks respecting this pomade :—

"'The planter who grew this root* sent also large consignments of CASSIE POMADE, the quality of which was excellent, and these have been continued and subsequent shipments made, but Mr. Umney learns that the planter referred to is now dead, and that his widow, who is at the present time in London, has given up the cultivation. It is a pity that the supply should cease, because from observations in the Laboratory of Wright, Layman and Umney, the produce from CASSIE FLOWERS grown in India was superior to that grown at Grasse, France; indeed Mr. Umney has been told that pomade was shipped from India to France, and subsequently shipped from Grasse to London, but of this he has no proof. His own opinion,

* *Podophyllum Emodi.*

CASSIE POMADE

however, of the value of CASSIE POMADE is quite confirmed by the eminent firm of Schimmel & Co., Leipzig.'"

"Although there is a very full account of the CASSIE FLOWER *(Acacia Farnesiana)* in the *Dictionary of Economic Products, Vol. I., page 48, et seq.*, where Piesse's opinion is quoted as to its value in perfumery, I have nevertheless thought it well to forward to the Government of India a copy of the opinion of Mr. Umney as to the excellence of the Indian product."

Although a good deal of attention has been given to this substance by myself and others, little progress has as yet been made toward establishing a trade in CASSIE POMADE. It is probable that in the plains of India a difficulty might be found to exist in preventing the lard or sweet oil, employed in the manufacture of the pomade, from becoming rancid. But in the lower hills or terai where this tree abounds or might easily be cultivated, a useful auxiliary crop to tea, coffee or even indigo might be found in CASSIE POMADE. For methods of cultivation and other details, *Conf.* with *Dictionary of Economic Products*, and *Odorographia* by J. C. Sawer, *pages 114-16.*

ACACIA JACQUEMONTII

Habitat.

ACACIA JACQUEMONTII, *Benth.; (Dict. Econ. Prod. I., 51)*.—Is a small thorny handsome shrub with stems and thorns polished and flowers sweetly scented; met with in the North-West Himálaya up to 3,000 feet in altitude. In the Punjab plains in Sind, in Rajputana and in North Guzerat it is often very abundant especially within water courses. It is known in Afghanistan as the *hanza*, but in the Punjab appears to bear, as a rule, the same vernacular names as *A. arabica*, although a sample recently came to the Office of Reporter on Economic Products from Amritsar under the vernacular names of *dhakki* and *chota-kikar*. In Rajputana it is called *baonli*; in Guzerat it is the *rato-baval*; in Baluchistan *har-barbara*; and in Sind *khunbut*. Captain M. A. Tighe, I.S.C., Political Agent, Southern Baluchistan, speaks of the gum of this tree as one of the spurious gum arabics which are known in that country as *khori-khor*. (*Report, dated 14th March 1898.*)

Fermentation.

In addition to the generic properties already mentioned as possessed by most species, the ROOT-BARK is stated to be employed in DISTILLATION of spirit. For some years past a considerable trade from Baluchistan and Sind has been done in the GUM of this species, exported from Karachi. Stokes (speaking of Sind many years ago) says that it is inferior to gum arabic but it is used in MEDICINE, calico-printing, and in paper-making. Captain Tighe (to whom reference has already been made) has much to say as to the difference between this and the true gum arabic (the *khor-ka-khor*) which see under *A. Senegal*, and also under COMMERCIAL GUM ARABIC. But it may be

Gum.

added in conclusion that Messrs. Rowntree & Co., Ld., of York, have pronounced the Amritsar samples (mentioned above) as the best of the series of Indian gums examined by them for the confectioner's requirements. "It is strongly mucilaginous and forms a thin jelly on standing with 10 parts of water. The solution is brownish but fairly free from sediment and the flavour is sweet." It has been ascertained that about 35 cwt. of this are annually procurable in Amritsar.

GUM. Suitable for Confectionery.

ACACIA LEUCOPHLŒA, *Willd.; (Dict. Econ. Prod. I., 52).*— A large deciduous fast-growing tree found in the plains of the Punjab and Rajputana, the forests of Central and South India and Burma. It prefers a low-lying situation and in the Punjab its presence is regarded as significant of a rich soil. Its branches are often disfigured by large excrescences. It is best known as the *safed kikar* or white *babul*, but in every province it has numerous vernacular names, of which the following selection may be made :—*Reru, raunj,* or *ronj, raundra, reunjah* or *ronja, rinjra* or *rinz, nimbar* or *nunbar, karir, jand, goira, arinj, topal, tumbe; tumma, hewar, hivar, haribaval, velvelam, tella-tuma, bili-jali, tanaung,* etc. etc.

A. LEUCOPHLŒA. Habitat.

In addition to the general properties possessed by most of the species of *Acacia,* Mr. J. G. Prebble says that it yields a GUM readily soluble in water and forming a good thick pale-coloured mucilage, possessed of the somewhat peculiar property that it is gelatinised by borax but is unaffected by ether, neutral or basic acetate of lead or perchloride of iron. It seems probable that owing to its close chemical affinity this gum is often largely used to adulterate the better qualities of *GUM GHATI* of commerce. The BARK affords a strong FIBRE said to be much valued for fishing nets. Ground to a powder it is sometimes eaten mixed with *bajra,* especially in times of scarcity. It has also attained a considerable reputation as an astringent used in alcoholic DISTILLATION. On this account it is often called *sharab-ki-kikar* (spirit-Acacia). The tannin precipitates the albuminous substances present in the saccharine juices, facilitates fermentation and is said to give a pleasant astringent flavour to the beverage. In the Southern Mahratta country the trees are farmed out by Government in consequence of the value of the bark. A distiller in South India recently informed me that he would use this bark more extensively than at present, were it possible to obtain a guarantee of quality. He held that while most Acacia barks might be employed in fermentation, that of the present species was so much superior to all others as to justify its being called *"THE DISTILLER'S ACACIA."*

Gum. Fibre. Food. Fermentation.

ACACIA MODESTA, *Wall.; (Dict. Econ. Prod. I., 53).*—Is a moderate sized tree found in the Saliman and Salt Ranges, the

A. MODESTA. Habitat.

ACACIA modesta.

Amritsar Gum.

AMRITSAR GUM.

Sub-Himalaya—between the Indus and Sutlej—and is one of the characteristic trees of the Northern Punjab plains. It grows readily in poor sandy or rocky soils. But curiously enough it is also found occasionally in very damp situations. Is a slow grower and in consequence not often planted, except as a fence for which it is peculiarly suited. It is perhaps best known by its Punjabi names of *phula*, *phulai*, *phulahi* and *bhamburi*, but it also bears the vernacular names of *kantosariyo* and *palosa*.

Gum.

It yields sparingly a very useful GUM which occurs in small round tears or angular fragments with a few vermiform pieces marked with waved transverse lines. Mr. Prebble says, "It is translucent and of a yellowish colour; very soluble in water forming a good pale-coloured mucilage. With basic acetate of lead and ferric chloride it forms a jelly but not with borax; with neutral acetate of lead a faint precipitate or cloudiness and a slight reduction with Fehling's solution. The gum is sent to Bombay from Northern India and is classed by the merchants as *AMRITSAR GUM*. The Punjab supply comes mainly from the Rawalpindi and Jhelum districts. In Northern India it is largely employed in MEDICINE. The tree affords also a very beautiful strong and durable TIMBER which is largely employed for cart wheels, sugar-cane crushers, agricultural implements, etc. The soft delicate twigs are employed as *tooth-brushes* especially in the Punjab.

Amritsar Gum.

Timber.

A. PENNATA. Habitat.

ACACIA PENNATA, *Willd.; (Dict. Econ. Prod. I., 54)*.—Is a large climbing shrub of the Sub-Himálaya, East Bengal, South India and common all over Burma. It is the *biswul*, *arar*, *shemb*, *undaru*, *gurwa*, *agla*, *awal*, *arfu*, *tolrik*, *thembi* and *su-yit*, etc. The BARK is an article of commerce, being exported from the Concan, and used to TAN fishing nets in Bombay.

Tan.

A. SENEGAL. Habitat.

A. SENEGAL, *Willd.; (Dict. Econ. Prod. I., 55)* —A low tree with grey bark and flexuose branches; met with, so far as India is concerned, in Rajputana and Sind, more particularly in the Las Bela country.

It yields the *TRUE GUM ARABIC* of European Commerce, and is known as *khor* in Sind (*khor-ka-khor* in Las Bela); and *kumta* in Rajputana.

For further particulars consult the chapter below devoted to "*COMMERCIAL GUM ARABIC*," p. 74.

A. SUMA. Habitat.

A. SUMA, *Buch.-Ham.; (Dict. Econ. Prod. I., 60)*.—Is a medium sized tree with white bark (a circumstance that gives origin to most of its vernacular names) and is common in Bengal, Behar, Assam and South India from the Carnatic to Mysore. Seems to luxuriate on moist soils in such places as vicinity of tanks, canals or streams. It

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BABUL.

is known as the *sai-kantz kumtia*, *dhaula* (white)- *khejra*, *gorado*, *sonkairi*, *gonharea*, *tella-sandra* (or *chandra*), *mugalisoppu*, *banni mara*, *mugli*, etc. Dutt says it is the *sami* of Sanskrit and the *sain* of Bengali and *chhikura* of Hindustani.

It possesses most of the generic properties mentioned above, but through being confused with *A. Sundra* (which see under *A. Catechu*) has by some writers been incorrectly spoken of as a cutch-yielding species.

A. ARABICA. The Babul or Kikar.

ACACIA ARABICA, *Willd.; (Dict. Econ. Prod. I., 17).*

This is the *INDIAN GUM ARABIC TREE* which, over the greater part of India, is known by the names *Babul or Kikar*. Dutt (*Hindu Mat. Med.*) gives it the Sanskrit name of *Vavula* or *babula* (a word which according to Rice is only Sanskritised), while Sir Walter Elliot (*Flora Andh.*) says it is the *Barbúrama* of Sanskrit. In South India it is known as *karú* (or *karuvelam*), *gobli*, *jáli*, *tumma*, etc.

A tree of Village Sites.

Habitat.—It is one of the most widely distributed and prevalent of small trees in India but chiefly on village sites, borders of fields or waste lands. It prefers a dry to a moist climate and accordingly is, as a rule, absent from the coast tracts; it disappears gradually from Bengal, Behar and Oudh, on the Terai being approached; is absent from the warm moist tracts of Assam, Manipur and Burma; is most prevalent from the North-West Provinces, through the Central Provinces to Berar, Central India, Bombay and Sind; and might be said to attain its greatest development in lower and middle Sind, where it is probably truly indigenous. It would not appear to be a native in many parts of India where it is nevertheless prevalent (such as the Punjab, Oudh, Bengal and Madras).

Kaulia and Telia Babuls.

Varieties.—Some short time ago Sir Dietrich Brandis, K.C.I.E., (*Indian Forester, Vol. XXIII., September 1897, page 359*) raised the question of the varieties of this species. He refers to the *kaulia babul* of Berar as a small tree with deeply cracked and exfoliated bark, broad marginate pods, and stouter spines than the ordinary form which in Akola is distinguished as *telia babul*. A third variety is the cylindrical *babul* known as *ram-kanta*. The *kaulia* or *kauria* is a smaller tree, grows on poorer soil, and affords a much less valued timber than the ordinary or *telia babul*. Sir Dietrich then offers the suggestion that the *kaulia babul* may be only a hybrid between *A. arabica* and *eburnea* In 1869 Stewart expressed the opinion that the variety *A. spina-alba* of Griffith, Jameson and Aitchison was no true variety but merely a long spined condition produced after being heavily pruned.

Shortly after Sir Dietrich Brandis' paper appeared, two Officers of the Forest Service took up the subject and confirmed his observations. Mr. R. Fagan wrote that he had been familiar with both *kaulia* and

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ACACIA arabica.

Cultivation.

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Vedi or Mad-babul.

The Godi Babul.

telia babul for the past 20 years and that they were distributed from Berar through Khandesh to Satara. In the Deccan the *kaulia* (or *kowri* or *kaoria*) becomes the *vedi* or *vadi*, *i.e.*, the mad *babul*, and the *telia* is the *godi* or sweet *babul*. In 1884 both Mr. Shuttleworth and Mr. Woodrow had alluded to these three *babuls*, only that the former came to the conclusion that the *vadi babul* was in reality *A. Farnesiana*. The cylindrical *babul* or *ram-kanta* is referred to by many persons and is believed to be the so-called Kabul *babul* of the Punjab or as it is sometimes called the cypress *babul*.

Conclusion regarding variety.

It would seem that the well known variability of *Acacia arabica* in merit of gum, tan and timber afforded, may to a large extent be dependent on this question of the varieties or climatic conditions of the species, hence this subject is well worthy of more careful consideration.

Soil.

Soil.—According to most observers it prefers a sandy light loam or black cotton soil to heavy clay, but appears to be somewhat indifferent to the presence of a fairly large percentage of *réh* or *shor* (efflorescent salts). But it does not succeed either on rocky and hilly ground or on low-lying and submerged tracts. On poor soils it may be grown as a means of reclamation, but plantations to be made profitable must be on fairly good soils. The yield and quality of the gum, of the tanning bark and of the timber—its three chief products—greatly depend on the healthy condition of the plants.

Successful Cultivation.

Enemies.—The life of the tree is generally said to be about 20 or 30 years; at all events after then it would seem to be very much addicted to the ravages of various pests among which the grubs of one or two longicorn beetles may be specially mentioned. Mr. Stebbing (*Injurious Insects of Forest Trees, pages 67 and 69*) describes these as *Cœlosterna spinata* and *Pachydissus holosericeus.* Its greatest enemy, however, (especially during the first 3 to 5 years of its existence) may be said to be the goat.

Longicorn Beetles destructive.

Methods of Sowing.

Method of Cultivation.—It is raised from seed, bears transplanting indifferently, but according to one writer in South India may be propagated by cuttings. Stewart made the same observation in 1869, *viz.*, that in the Gangetic Doab it is raised from cuttings. It can be drill sown or broad-casted, in either case just before the rains or, say, in June to July. It germinates slowly, as the seeds are exceedingly hard. Accordingly it is customary to soften them by steeping for a day or so in water or in liquid cow manure. The seed is generally gathered in April, and by the Native cultivator is often coated with cow-dung and kept in that condition till July when it is sown on the spot where it is intended to be grown. Most writers affirm that germination is best effected by making goats or sheep first eat the seeds. This is, however, a mistake, for these animals will not eat the

Season.

Methods of Germination.

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shelled seeds and do not care much for ripe pods; they prefer green pods with immature seeds. When the seeds are mature they eject them from the mouth during rumination, and the seeds thus never actually pass through the alimentary system. Having, however, been retained, perhaps for some hours, in the first stomach of a ruminant they will be found to germinate freely. **CULTIVATION.**

The plants have to be weeded and thinned out till the third year when the healthiest only should then occupy the ground at distances of from 10 to 15 or even 20 feet apart. In the third year they will flower and bear fruit and, according to the experts of the tanning industry in Cawnpore, the bark is in its most perfect condition when the trees are from 4 to 6 years old. Curiously enough many of the Native opinions recorded in the papers in my hands affirm that the older the trees the stronger the tanning property. This would appear to be a mistake, the colouring principle develops, but the tanning value decreases with age. If, therefore, *babul* plantations be raised, with a view to returns from tanning-bark and fuel, the maximum age to uproot should be from 6 to 10 years. **Weeded out.** **Perfect Condition of Bark.** **Proper Age of Plantations.**

At one time it was supposed that a system of pollarding a plantation might be the most remunerative, but plants so treated have been observed to grow so very slowly afterwards that it has been concluded the preferable course is to uproot and replant. In localities where bark is not very largely in demand it is sometimes stripped off the living plants, but the wounds heal so very badly that this is by no means an approved method of procedure. **Pollarding Plantations.** **Stripping Bark.**

Cost of Production and Profit.—Mr. Ozanne (*letter No. 607, dated July 1884, para. 16*) furnishes returns given by a Parsi gentleman of Guzerat. Briefly these may be said to show the cost of cultivation and rent of an acre of land for 10 years as R24. Gross proceeds for grazing and fuel R251, thus leaving a net profit of R227. Dr. Leather (*The Agricultural Ledger, No. 18 of 1896, page 4*) shows the working expenses for an acre of land in Agra under *babul* to have come to R146 and the gross receipts R440 so that the net profit in 10 years came to R294. But in neither of these cases does credit appear to have been made for the sale of bark, the plantations having apparently been undertaken purely and simply for fuel purposes. Reference will be found below to the Unao plantations under the paragraph devoted to agriculture, page 73. **Cost.** **Profit.**

The voluminous papers at my disposal manifest the following particulars that have a bearing on the question of profit in cultivation. In Bengal a full grown tree (20 years old) may fetch R4. In the North-Western Provinces (in the vicinity of Cawnpore) a tree 6 years old would realize R3, but less at a distance from that town. In the Central Provinces each tree is valued at R2 to R4 according to **Cost of Trees**

ACACIA arabica.

Cost of Production.

BABUL.

size and quality. In Rajputana and Central India the majority of the reports to hand would seem to denote a much higher valuation, namely, R15. In the Punjab a wide range has been recorded from R8 in Multan to R50 in Delhi, but all the Punjab papers speak of a full-grown tree being from 40 to 60 years of age and as yielding fairly large and much valued timber. It is admitted that trees from plantations only 10 to 15 years old might not realize more than one rupee each. In Bombay Presidency a similar valuation is given to that of the Punjab; very old trees perhaps 50 or 60 years of age with useful sizes of timber would fetch from R40 to R100 each. Mr. Shuttleworth says an acre of land specially grown for fuel supply might give an annual net profit of R12 and might continue to do so for 40 years. In Berar the returns indicate an average value of R2 to R4, though as much as R20 has been known to be paid for old trees. They are believed to attain full growth in 20 years. In South India (Northern Forest Circle) well-grown trees of 40 to 50 years are believed to bring as much as R30 to R40 or even up to R100 each.

Age of Babul. *Price of Babul Trees.* *Profit of Fuel Cultivation.*

It may thus, in conclusion, be said that on good soil the tree is much less gregarious, is allowed to grow to a fairly large size and is accordingly valued more as a timber tree than as a source of fuel. The variety (mentioned above) as *kaulia* or *vadi* is that usefully grown in Berar and Western India when fuel only is desired. The *telia* or *godi* is the form that is ordinarily allowed to run to timber. Success in cultivation would seem to depend upon several circumstances such as the scarcity of, and consequent high price of fuel: a good market for the bark: the existence of suitable land at low rents, etc., etc. If other fuel be fairly plentiful or if cheap waste lands be not available, the tree takes its place on the margins of fields and roadsides more as a source of timber and gum, than of fuel and tanning bark, and the *telia* variety would be that most generally met with under such circumstances. But it must never be lost sight of that, to be successful, production of *babul* fuel and *babul* bark must be in close proximity to the markets, since neither product could bear heavy railway freights. So also it may be added that in fuel-yielding tracts (or plantations) gum is rarely produced to any appreciable extent; the supply of that product has to be looked for mainly from the more natural habitats of the plant, especially the arid tracts of its indigenous distribution as a forest tree.

Babul Timber. *Success in Cultivation.* *Gum Rarely Obtained.*

The products and uses of Babul may be dealt with under the following headings:—

1ST.—*THE GUM.*

GUM. Seasons of Flow of Gum.

GUM exudes in March, April and May, according to the vast majority of reports, but in connection with Amritsar it is said that

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Varying Quality of the Gum. (*G. Watt.*) **ACACIA arabica.**

GUM.

it oozes from the trees in the months of October, November and December. A tree yields a maximum of about 2 lbs. a year, but the average might be more safely put at a few ounces. In certain localities little or no gum is given by the trees and seasonal variations in yield are also well-known and are said to be dependent on abnormal climatic conditions. It is generally believed that the flow is accelerated on the trees being tapped, still this is only very occasionally done, and, when practised, may be detected by the presence of long stalactiform masses.

Yield of Gum. **Accelerated by Tapping.**

The gum occurs in the form of irregular and broken tears, agglutinated into masses, each tear being $\frac{1}{2}$ an inch in size and of a pale straw colour to red, brown or almost black, according to the age of tree on which found. The older the tree the higher the yield, but the darker the colour and the poorer the quality of gum. That is the general opinion, but the Amritsar report states that old trees do not yield any gum at all. Long exposure to the atmospheric influences, more especially to damp and rain, darkens the colour and lowers the value of the gum besides making it astringent, from the quantity of tannin with which it becomes charged. It has also been observed that gum exuding from gnarled stems or diseased portions is dark coloured.

Appearance of Gum. **Atmospheric Influence.** **Dark Coloured Gum.**

The purer and paler coloured samples reduce Fehling's solution only slightly, and are darkened in colour by ferric chloride and gelatinised by borax. The darker coloured samples (highly charged with tannin) are precipitated by basic acetate of lead, form inky colorations with ferric chloride, deep brown with bichromate of potash and red with molybdate of ammonia. They freely reduce Fehling's solution. Moreover, the darker coloured portions are much less soluble in water and leave a gelatinous portion undissolved.

GUM. **Chemical Reactions.**

Indian gum arabic is used in calico-printing and in all other industries where a mucilage is necessary and in which the peculiar properties of this particular gum are recognised as specially suitable. Among other minor purposes it is, for example, employed as an ingredient in white-wash and in paints used for wall-distempering. It is added to certain mortars and to paints that are used for clay toys. As a MEDICINE it is an indifferent substitute for the true gum arabic of European pharmacy (see the article below). Still when fairly pure it may be said to be regarded as demulcent and to be suitable for use as a vehicle for bismuth, oxide of zinc and other insoluble substances. It is often used as a vehicle for castor oil and has the merit of absorbing the offensive smell. One drachm of gum dissolved in $\frac{1}{2}$ oz. of water will carry 1 oz. castor oil. Employed in lozenges its very much lower solubility than the true gum arabic tells distinctly against it.

Industrial Uses. **Medicinal Uses.**

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Price of the Gum.

BABUL.

Famine Food

It used to be affirmed that in times of scarcity the gum formed an important item of human FOOD, but recent inquiry has brought a flat contradiction of that statement from almost every district in India. The gum at all seasons is several times more expensive than the grains eaten by the poorer people; they would, therefore, preferably purchase grain with it. It is nowhere so abundant as to become a famine food. It is, however, unquestionably edible, and fried with ghi, sugar and spices, it is very largely employed in the preparation of certain Native sweetmeats which are very generally eaten after child-birth.

Sweetmeats.

Confectionery Trade.

The investigations so far as they have proceeded into the Indian gums suitable for the European confectionery trade, have revealed several very surprising circumstances connected with this gum. There are, for example, great variations in quality which are not alone accountable for by adulteration with inferior gums. Not only does the quality depend largely on the age of the trees and the variety of tree, but on the province in which procured. Thus, for example, two samples, one said to have been the best quality from Nagpur, and the other from Cawnpore (both believed to have been authentic samples of *Acacia arabica* gum), were forwarded to Messrs. Rowntree & Co., for examination and report. The reply in due course came—"They gave exceedingly dark solutions of medium strength, but both are quite useless to us on account of the colour." A third consignment procured from the Punjab was said to give "a pale solution, very thin and probably of little value for any purpose." The best edible gum, from Messrs. Rowntree & Co.'s standpoint, is that already referred to under *A. Jacquemontii.* It would thus seem that so far from *Acacia arabica* affording the best gum arabic of India, it might almost be described as the least important species of the genus, from the point of view of an edible gum. But it seems probable that *babul* gum from Sind may be of a much superior quality to that from other parts of India. This subject has by present inquiry been by no means exhausted. Much has still to be learned regarding the variations in quality and best localities of supply. As met with in trade the gum comes mainly from the Central Provinces and Berar and is known in Bombay as *Umrawatti* and *Amrad.*

Best Edible Gum.

Umrawatti Gum.

PRICE OF GUM.

Price.—The information available regarding the price at which the gum can be procured is so conflicting as to be practically worthless. At Bilaspur (landed at the nearest railway station) the price would be R25 per 100 lbs., while at Nagpur only R12-8. At Shahpura the gum is said to cost about R20 per 100 lbs. Of Lahore it is reported that local production hardly suffices to meet the demand and that it sells for from R18 to R24 per 100 lbs. In Amritsar it is

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TAN.

procurable at R26 per 100 lbs., but the supply is very limited. At Poona when available it costs about R40 per 100 lbs. In most districts of Berar the gum is reported as rare and hence expensive, say R50 per 100 lbs. This is very surprising, seeing that Bombay is said to draw its chief supply from Berar and the Central Provinces. From the Kistna district comes the report that the gum sells at R3 per 25 lbs., or at the same price as recorded in connection with Nagpur. Unfortunately separate returns regarding this gum have not been obtained from Sind, the region of greatest interest.

2ND.—*THE TANNING AND DYEING BARK.*

BABUL BARK. Tan.

BABUL-BARK is perhaps one of the most extensively used and most highly valued of the crude tanning materials of India. It is in fact with the Native tanners the chief tanning substance in practically all provinces except South India where its place is to a large extent taken by the TANNER'S CASSIA (*Cassia auriculata*). It is also very extensively employed by the dyers because of the rich colours it affords.

In a review such as the present (intended to give only the most elementary sketch of the practical or commercial facts regarding the economic products of India), space cannot be afforded for the methods of dyeing and tanning pursued, nor for the formula of the special preparations employed. The reader must consult the *Dictionary of Economic Products* and other such works for all details.

Sources of Bark.

Tanning Bark.

Ages of Trees.

The introductory paragraphs of the present article have already set forth some of the practical considerations regarding production of *babul*-bark. It is commonly obtained from trees felled for fuel and the bark very often becomes the woodman's wages. To a small extent it is stripped from growing trees and occasionally trees are pollarded and the bark of branches used as the tanning substance. So again the observation has already been made that the bark from old trees is not so valuable as that from trees 6 to 10 years of age. In order, however, to obtain perfectly trustworthy information on this point an extensive series of barks from a selected number of districts were procured from trees of various known ages and during certain fixed seasons of the year. (See *The Agricultural Ledger, No. 9 of 1896, pages 4 and 16-17.*) These were forwarded to the Imperial Institute, London, for analysis, and it is believed Professor Wyndham R. Dunstan's report, when procured and published in *The Agricultural Ledger* will throw much useful light on several obscure points regarding the future supplies of this tanning material. The inquiry has already been prosecuted sufficiently far to reveal the circumstance that *babul*-bark is hardly ever likely to compete successfully against the tanning materials already procurable

Experiment to Test Yield.

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Price of Bark.

BABUL.

Cannot be Exported.

in Europe, and that very possibly it will never even pay to manufacture for export a tanning extract from this bark or from the bark and pods combined. Much has been written on this theme, but it may be said the claims of *babul*-bark turn, on its cheapness and abundance, but it is bulky, and the percentage of tannin small, hence it cannot be profitably carried for more than short distances. Accordingly it may be said that *babul*-bark is a tanning material of great local value, but one that is hardly even likely to be exported to foreign countries. It contains 18·95 per cent. of a tannin which is of a beautiful cream-colour when precipitated with gelatin.

Percentage of Tannin.

Price and Supply.—Very little of a definite nature can be published on these subjects. It has been reported recently that the annual consumption in Cawnpore alone is over 200,000 maunds, valued at eight annas a maund. But Cawnpore is the great tanning centre of India and its transactions represent, therefore, a very large slice of the total traffic in the bark. At Dumraon in Bengal, *babul*-bark is said to be sold at R1-10-0 per 100 lbs. At Bundelkhand it can be had for 6 annas a maund. In the Central Provinces the bark is valued at R1-4-0 per 100 lbs., while at Shahpura in Rajputana the same quantity costs R2-4-0. At Lahore it is said the annual sales of bark average 4,000 maunds at 8 annas a maund. Mention is made of 1,500 maunds as the Delhi supply and that it there sells at 13 annas a maund. At Poona the bark fetches 12 annas to R1 per 100 lbs. These and such like are the returns that have come to hand, and they afford very little of a trustworthy nature, further than that it is a local product that in point of price is, like most other commodities, influenced by the laws of supply and demand.

Local Prices.

Fermentation.

As with most other species of Acacia the bark is employed in FERMENTATION, hence some of the reports speak of it as affording Yeast. Some 2 to 3 seers of the crushed bark are required for one maund of *gur* (undrained sugar) or *shira* (molasses) and 3 maunds of water. This mixture has to be kept for 7 or 8 days in summer or for a few days longer in winter, before fermentation is complete. But it seems to be generally admitted that for this purpose *babul* bark is much inferior to that of *A. leucophloea.* A distiller in South India informed me that the chief obstacle to an extended use of Acacia bark was the difficulty in procuring the right kind in sufficient quantity.

Medicine.

Babul-bark is extensively employed as an astringent MEDICINE. As a substitute for Oak-bark and galls in external application it would seem fairly satisfactory. The bark boiled in soap and water is a useful preparation in which to wash dogs, horses, etc. Reduced to ashes it forms a useful tooth-powder.

Tooth Powder.

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3RD.—THE POD.

PODS.

The PODS attracted much attention in the 1884 inquiry on account of an absurdly high valuation as a tanning material having been attributed to them. It was then affirmed that the crushed pods freed from seed would fetch £40 a ton or 50 per cent. more than was then being paid for oak-bark! This naturally led to numerous experiments being performed to test the yield per acre, the cost of production and methods of crushing and baling the material. When the report called for finally came to hand from England, *babul* pods ceased to attract attention; they contained at most $9\frac{1}{2}$ per cent. of tannin and could not bring £10 a ton. All interest in the subject died as quickly as it had burst into spurious attention. *The Agricultural Ledger No. 9 of 1896.* may be consulted for further particulars.

Spurious Repu tation.

Percentage of Tannin.

But crushed *babul*-pod imparts a beautiful colour to leather, and on that account mainly it enjoys a certain local reputation as a weak tanning and dyeing material to be used in conjunction with other substances. At the Cawnpore Tanneries the pods are used almost exclusively for the purpose of removing the lime from skins and hides preparatorily to being tanned with *babul*-bark or other substances. The dyers of India often employ *babul*-pods for certain shades that are admired in calico-printing.

Uses.

From the immature pods by inspissation, an extract may be prepared. This was known to the ancients and through the Greeks reached the Arabs to whom it was known as *Akakia*. To this day a DRUG comes to India under that name from Turkey and Persia and is sold by most Muhammadan druggists. It is considered cold and dry, astringent, styptic and tonic, and is used both internally and externally in relaxed conditions of the mucous membranes and as a collyrium in purulent conjunctivitis and chronic congestion of the vessels of the conjunctiva. Applied as a lotion to the face it is believed to improve the complexion.

Medicine.

Akakia.

Cosmetic.

The unripe pods, reduced to a powder, are used as a domestic medicine in all cases where an astringent is indicated. They are employed in the manufacture of tooth powder and along with sulphate of iron in the preparation of ink.

Tooth Powder.
Ink.

The tender young pods are EATEN as a VEGETABLE, especially in times of scarcity. They are often pickled (*achár*) and viewed as a luxury, especially by the Marwaris. The green pods with their seeds are regularly eaten as FODDER by goats, sheep, cows and camels By most persons they are said to be strengthening and to be especially useful as an occasional diet for milch cattle. But if fed on them for any length of time, the pods are supposed to become injurious. From Madras has been received the statement that fatal cases have

Vegetable.
Pickle.
Fodder.

ACACIA arabica.

Tanning Leaves.

BABUL.

Dangerous to Cattle at times.

been known to occur from cattle eating the seeds. In Sind the green pods are much appreciated, as may be learned from the following passage from a report by Lieutenant-Colonel J. G. McRae (dated 1884):—

Much Valued.

"*Acacia arabica* yields a very abundant crop of legumes in the early part of the hot weather, during April and May, the sale of which forms an important item in the forest revenue in this Province. It is quite impossible to estimate the quantity of babul pods the forest yield yearly, as they are disposed of by giving yearly leases of the forests for the right of gathering the pods for cattle fodder, and as the cattle in this district depend very greatly on these babul pods for green food, and often food of any kind, during the hottest and driest season of the year, I trust no facilities will be given, in diverting this important, I may say indispensable, fodder-supply from the use to which it is at present put."

LEAVES OF A. ARABICA.

4TH.—THE LEAVES.

Tan. Dye. Ink.

Most of the older writers speak of the LEAVES of this tree being also used as a TAN, but according to the voluminous opinions recently to hand this would appear to be a mistake. They are sometimes used in DYEING and are often also employed in the manufacture of ink so that they do possess tannin, but in such small quantity to be useless as a tan. A few writers speak of the leaves, pods and bark being used conjointly by certain Native tanners, but apparently only when they are unable to procure enough of the bark to be employed by itself.

Fodder.

The chief value of the leaves is as a FODDER, especially in times of scarcity or famine. Beaten from the lopped and dried spinose branches they are regularly given to cattle. Although the tree is never leafless, fresh foliage appears from February to April. The value of this source of fodder when rain fails cannot be overstated as the tree is little, if at all, affected in its production of foliage by failure of rains.

Medicine.

In MEDICINE the leaves also find a fairly well recognised position. They are employed (as also the fresh juice expressed from them) in diarrhœa and dysentery and in the early stages of gonorrhœa. A paste of the leaves is employed in opthalmia and it is also very frequently used as a stimulating application to ulcers.

Madak.

The leaves constitute an ingredient in the intoxicating drug of Indian-hemp known as *madak*, and it is said that in a similar way they are also made up with opium. One writer speaks of them as smoked like tobacco but doubtless only in some such intoxicating preparations as those already mentioned.

TIMBER OF A. ARABICA: Agricultural Implements.

5TH.—THE TIMBER.

This TIMBER is highly appreciated for all forms of agricultural implements because of its hardness and durability. It is specially valued for CART WHEELS. In Bengal, the North-Western Provinces

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TIMBER. House Construction.

and the Central Provinces the timber is rarely, if ever, employed in house construction or for furniture, as it is supposed to be a very unlucky timber. But in the Panjab, Sind and Bombay no such superstition exists, and accordingly it is frequently utilised in house building and is much appreciated where great strength is desired. In Bijapur it is much in demand for the construction of the carts for which that town is famous. When used for furniture the timber is carefully seasoned in water.

Method of Seasoning.

Fuel.

As a source of FUEL or CHARCOAL *babul* justly holds a high position in popular favour. Accordingly its cultivation in the vicinity of all large towns would seem highly profitable. An average sized tree will give 5 maunds of fuel besides branches and bark that fetch additional returns. Some few years ago a scare was started by the Madras Railway that *babul* fuel injured the boilers. This point has been freely discussed in the papers on my table. The practical result may be said to be the conclusion that as compared with coal all forms of wood fuel are injurious, but that *babul* timber has so high a calorific value that it is not only extensively used at the cotton and other mills and railways of Upper India, but would be more extensively employed were it procurable.

6TH.—MINOR INDUSTRIAL AND AGRICULTURAL USES.

MINOR USES OF A. ARABICA.

Mention has been made of babul gum being used in the manufacture of wall distempers, in paints; and of the pods and leaves being employed in ink, in tooth-powders, etc., but one of the most widely known of the minor uses of the plant is as tooth-brushes. Short twigs are made up into small bundles of about 100 each and in that form are exported as a regular article of trade from Karachi to Bombay and practically all over India. They are very extensively in demand by the Marwaris; the end is chewn until it forms the brush. Baskets are also plaited of young green babul twigs, and very strong and durable they are. Fishing traps are in some parts of the country similarly constructed of them, and the spines are occasionally employed as fishing hooks and as pins to sew together leaves used as platters. Crude ropes are sometimes made of the bark fibre, and in Poona it is said the fibre from the root is specially prepared to ornament the horns of bullocks during the *palwa* festival.

Tooth Brushes.

Baskets.

Fishing Hooks.

FIBRE.

In Sind (and to some extent also in the Panjab) *babul* is one of the important trees on which the Lac insect is reared. The reader will find full particulars on this subject in *The Agricultural Ledger, No. 9 of 1901.*

LAC.

To the Indian cultivator *babul* is of the greatest possible value. It does not afford much shade, and yet curiously enough very little, other than grass, will grow underneath it. On this account it is rarely, if ever, allowed to get established in the middle of fields.

AGRICULTURE. Shade.

ACACIA Senegal.

Commercial Gum Arabic,

TRUE GUM ARABIC IN RECLAMATION OF WASTE LAND.

For avenue purposes, where shade is desired, it is not accordingly a desirable tree. But in the reclamation of waste lands *babul* is invaluable especially where *reh* efflorescence gives cause for anxiety. Grass rapidly becomes associated with it so that grazing affords a distinct source of revenue in *babul* plantations. In the *Indian Forester* (*Vol. XXVI., April 1900*) Mr. B. Ribbentrop, C.I.E., gives some interesting particulars regarding the *babul* plantation at Abbaspur near Unao, organised by Mr. Moreland, Director of Agriculture in the North-Western Provinces and Oudh. This was laid out for reclamation purposes, namely, on a shallow surface soil underlaid by clay or *kanker*, impenetrable to the tap-root of the tree. Pits were dug through the impenetrable layer, fresh soil was supplied and trees planted. This came to a cost of 10 annas each, but apparently so great an outlay stands every chance of proving a financial success. The land was otherwise useless and at the time of inspection the trees looked fairly healthy.

Hedge.

Fences.

Sown thickly as a hedge, *babul* forms a great protection both against animals and parching, dust-laden winds. As dead fences, the spiny boughs are universally employed to afford temporary protection to valued crops. For these and such like reasons extended cultivation of this tree should invariably be commended in all suitable localities.

A. SENEGAL.

ACACIA SENEGAL, *Willd.* (*Dict. Econ. Prod., I., 55-56*).—*THE COMMERCIAL GUM ARABIC.*

COMMERCIAL GUM.

Before concluding this brief review of *Acacia arabica* it seems desirable to bring together a few of the more important facts known regarding India's participation in the world's supply of *GUM ARABIC.* But let it be premised that it is an unfortunate circumstance that Arabia has become associated with this gum, since no portion of the commodity comes from that country and, moreover, the species that bears the name *arabica* is perhaps the least important of the gum-arabic-yielding plants. There may be said to be three chief forms of this gum:—1st, *TRUE GUM ARABIC OF EUROPEAN COMMERCE;* 2nd, *THE EAST INDIA GUM ARABIC;* 3rd, *THE INDIA GUM ARABIC* often collectively called *"GUM GHATI." THE TRUE GUM ARABIC* is obtained from *A. Senegal, Willd.*, and there may be said to be three forms of it:—

Three Forms.

Gum Senegal.

1st: True Gum Arabic.—(*a*) *Gum Senegal* the *verek* of the Negros. This comes from the French Colony of Senegal (on the West Coast of Africa). It is collected after the close of the rains in November up till July. It is found to exude in greatest abundance during the dry desert winds and is most frequent at the bifurcations of the branches. The gum is shipped chiefly to Bordeaux. It is usually of a yellowish to a reddish colour and occurs in larger lumps

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than Turkey gum, roundish or oval or even elongated, pulverisable and less brittle than Turkey gum and distinguished by the absence of the numerous fissures so characteristic of that gum. TRUE GUM ARABIC.

(*b*) *Kardofan or Turkey Gum.*—This is known in East Central Africa by the name *hashab.* It comes from the mountainous tracts of Kordofan on the Upper Nile and almost in the same latitude as Senegal through across the vast Continent of Africa to the North-Eastern Division. The most highly prized quality comes from Dijara. This is generally conveyed down the Nile to Egypt and thence exported to Europe. It occurs in round lumps, often as large as a walnut or in irregular broken pieces, pure white, very much fissured, especially on the surface. This gum is most frequently used for medicinal purpose and may in fact be regarded as the true officinal Gum Arabic of England, India and America. Kordofan Gum. Officinal Gum Arabica.

(*c*) *Suakim, etc.*—But in addition to Senegal and Kordofan gums other inferior qualities are known in trade such as *SUAKIN GUM.* This consists of various sorts, for example the *SENNAAR* and the *BLUE NILE* (between Khartoum and Berber). From being exported from Suakim these all come to bear that name. Then again there is the *BARBARY* or *MOROCCO,* or *MOGADOR GUM.* This is a brown-coloured gum, derived from a form of *Acacia arabica,* and it usually reaches Europe from Morocco. This bears the vernacular name of *attaheh* and is collected during the hot months of July and August. It is usually of a brownish colour and found in small angular or broken pieces. It has a faint smell and when fresh constantly produces a crackling noise. Suakim Gum. Barbary Gum.

2nd: East Indian Gum.—Attention may now be directed to *EAST INDIAN GUM.* This is entirely imported into Bombay in the first instance, from Aden and the Red Sea ports,—no part of it being produced in India. There are two qualities, *viz., maklai* and *maswai.* The former exists in large round tears or vermicular pieces, white, yellow or reddish. Is much like Gum Senegal but more fissured. It derives its name from Makalla the port from which it is mainly shipped. The latter exists in angular fragments and vermicular pieces and in colour may be white, yellow or reddish. It derives its name from the port of Massowa. Both of these are good soluble gums, very little inferior to true Gum Arabic. They are picked and assorted, then re-exported from Bombay as *EAST INDIAN GUM.* EAST INDIAN GUM. Two Qualities.

3rd: Indian Gum Arabic.—Lastly, we come now to the *INDIAN GUM ARABIC* or *GUM GHATI.* It would seem that in contradistinction to the gums that reach Bombay by sea, those that come by train or down the ghâts are collectively designated *GUM GHATI.* This would embrace very possibly a wide range of gums (besides those obtained from species of Acacia) and very often it is believed degrees of quality INDIAN GUM ARABIC. Quality.

ACACIA Senegal.

Gum Ghati.

INDIAN TRUE GUM ARABIC.

Indian Method of Collection.

must denote the extent of admixture rather than the nature of specific variations. Gum when detected is gathered casually by women and children or by the shepherds and is sold in small quantity to the nearest shopkeeper. It is then conveyed to the next larger dealers and so on through many hands until the produce of a wide area and a multitude of diverse gums get hopelessly intermixed. Nowhere in India is gum systematically produced and indeed hardly anywhere in this country could it be said that arborescent vegetation was so exclusively of one gum-yielding tree as to admit of a large uniform and constant supply being organised in any particular gum.

Difficulties of Trade.

Bombay Gums.

Mr. J. G. Prebble (in the paper to which reference has already been made) describes 27 gums as met with by him in Bombay. These include *Acacia arabica, A. Catechu, A. Farnesiana, A. leucophlœa* and *A. modesta.* To that list must be added two and perhaps the most important of all, *viz., A. Jacquemontii* and *A. Senegal.* The reader should consult the remarks already made for the specific peculiarities of these gums. The present observations are intended to deal with them collectively as constituting the superior qualities of *INDIAN GUM ARABIC. A. Jacquemontii* reaches Bombay as one of the "Amritsar gums" and is also very largely exported from Karachi as "Sind gum." *A. Senegal,* though it has not as yet received separate recognition by Indian merchants, is a gum of great merit and one which might fairly well be removed from its present obscurity and treated as *INDIAN TRUE GUM ARABIC.* The chief supply comes from Sind, but as the plant is fairly common in Rajputana it is also no doubt obtained from that region in mixture with the gums of other Acacias.

Indian True Gum Arabic.

Beluchistan Supply.

Some short time ago Captain M. A. Tighe, I.S.C., Political Agent, Southern Beluchistan, was induced to give attention to this subject. He ultimately furnished me with admirable samples of the gums and with corresponding botanical specimens of the plants from which these gums had been procured. The two gums in question were thus definitely determined as follows:—*khor* (or *khor-ka-khor*), *Acacia Senegal* and *harbarbara, A. Jacquemontii.* The following passages from Captain Tighe's report will, therefore, be read with much interest:—

Two Kinds.

"I found that gum was exported from Las Bela to Karachi and that among the Hindu traders two qualities were recognised, the TRUE and the SPURIOUS."

"The former (vernacular—*sacha khor*) is the product of a tree that I have ascertained to be *Acacia Senegal* and known as *khor* in Las Bela and Sind. The latter or spurious gum (*khori khor*) is presumably the product of the common *babul* or *kikar, A. arabica,* and another species of *babul* locally known as *harbarbara* or *Acacia Jacquemontii.*"

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INDIAN TRUE GUM ARABIC.

"Dr. George Watt has pointed out that Gum Arabic is a natural product of India, but that it has failed to find a good market owing to the mixing of all kinds of gum in India. Now in the levy tracts of the Sind Bela border it would be a simple matter to prevent this adulteration, as, from my observations, I think it would be easy to control the collection. In the Khudho hills, I did not see any other Gum-bearing trees with which the true *Acacia* could be confounded. Lower down towards Karachi, in the Chutta country, the *harbarbara* becomes apparent in the beds of the water courses, but the true *Acacia* was just as frequent on the hill sides." **Adulteration.**

"The hills were plentifully covered with the latter. I do not mean to say the hills were clothed with vegetation, as they look bare at a distance of 3 or 4 miles, but on approaching them you can see a goodly show of trees, and I should say 75 per cent. or more were *A. Senegal.*" **Percentage of Trees.**

"There is no regular collection of the gum. Women and shepherds occasionally collect a little and barter it to the *banias* for anything they may want. The latter accumulate whatever is brought until they have sufficient to take to Karachi. The collection is thus made casually by *banias*, who sell it to the leading Native firms in Karachi who in turn sell it to the European merchants." **Method of Collection.**

"I do not place much reliance on information regarding prices given me by *banias*, but according to them, they get at R13 a maund. I heard they were getting R16 and 18 per maund for the first sort, R10 and 12 for the second sort." **Price.**

In a later communication Captain Tighe writes :—"The Bela officials do not seem to have taken a very lively interest in the matter. In obtaining the samples they have depended chiefly on the *banias*, while it may be supposed they are not likely to regard favourably the exploiting by the Sirkar of a field that, as far as it goes, brings them in a considerable amount of profit for a minimum outlay." "I must add, however, that at this particular moment the various trees are almost entirely destitute of gum. This is owing, I believe, to the scanty rainfall of the past season. Had the monsoon rains been more plentiful, the period after their cessation, *viz.*, October onwards, would have been the time for the gum to appear. Unfortunately even the winter rains have failed and I fear that some still further delay must occur before the required specimens can be furnished." **Influence of Rainfall.**

Captain Tighe's description of the country, of the season of flow of gum, and its dependence on rain, will recall the conditions that prevail in the regions where the *True Gum Arabic* is produced. I may add, in conclusion, that in Karachi the merchants were found by me to be far too indifferent to the desirability of encouraging and developing a trade in the true gum as compared with the spurious. The fact that there were two widely different qualities was fully recognised, but the prices offered for the one as compared with the other, could hardly be regarded as calculated to encourage their

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ACACIA Senegal.

Trade Returns.

INDIAN TRUE GUM ARABIC.

being kept distinct. Curiously enough far to the South at Tuticorin, I found a modern trade in gums being encouraged on a much more healthy basis. Considerably different prices were paid for the various grades and at least one firm employed a staff of persons to hand-pick and assort the gums they had purchased. I was unable to ascertain the species of plants that afforded these South Indian gums, but one or two at least must have been *Acacias* and very possibly were *A. ferruginea, Latronum, leucophlœa, Suma* and *Sundra.* Perhaps of these the most important would be the last mentioned which is the South Indian variety of *A. Catechu* and is an abundant tree from Coimbatore, northwards to the Deccan and Guzerat. It is known to yield gum freely and of a very good quality.

South Indian Trade.

TRADE IN INDIAN GUM ARABIC.

Trade Return of Gum.—During the past six years the exports of *INDIAN GUM ARABIC* to foreign countries have thus fluctuated; in 1895-96, 32,236 cwt. value R7,72,642; in 1896-97, 58,769 cwt. value R13,79,693; in 1897-98, 46,525, value R906,178; in 1898-99, 41,469 cwts., value R7,14,632; in 1899-1900 46,254, value R7 70,947; and in 1900-1901, 37,553 cwts. value R699,883. There has consequently been a decrease in value. These exports may be analysed thus, in 1900-1901, 37,045 cwt. were sent from Bombay, 371 cwt. from Karachi, and 133 cwt. from Madras ports, with 4 cwt. from Bengal. The trade thus centres mainly in Bombay. The following facts may now be given of the foreign gums imported into India, and again re-exported as *EAST INDIAN GUM ARABIC*:—The imports from Aden, African, and Red Sea ports in 1895-96 were 5,627 cwt. value R1,04,838 and in 1900-1901, 2,355 cwt. value R49,879. There has thus been a decline in the imports of foreign gums by sea. But during the same period 11,400 cwt. value R1,72,991 and in 1900-1901, 12,171 cwt. value R1,61,355 were re-exported, and the difference between the imports of foreign gums and the re-exports must represent (1) the foreign gums brought to India across the land frontier; (2) the varying extent to which stocks on hand are spasmodically drawn upon; or (3) the adulteration with *INDIAN GUM ARABIC.* But the re-export trade fluctuates very greatly, thus from the figure given above for 1895-96, it fell to 7,391 cwt. in 1896-97, to 5,951 cwt. in 1897-98; then rose to 7,297 cwt. in 1898-99, and to 16,781 cwt. in 1899-1900; falling again to 12,171 in 1900-1901. If any reliance can be put on the declared valuations of these gums, it may be pointed out that the imported gum is the highest priced; that the *INDIAN GUM ARABIC* is next most expensive; and that the re-exported or *EAST INDIAN GUM ARABIC* is the least expensive of the three qualities shown in trade returns.

Re-Export Trade.

The figures here discussed are those given for Gum Arabic not the "Other Gums" and "Resins" which are recorded as imported and exported to and from India.

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Geographical Distribution. (*G. Watt.*)

ACACIA Catechu.

VARIETIES.

ACACIA CATECHU, *Willd.; (Dict. Econ. Prod. I., 27-44);* Prain, *Some Additional Leguminosæ (Journ. Asiatic Soc. Beng., Vol. LXVI, Pt. II., 1897, pages 508-9).*

The *CUTCH* or *CATECHU* tree throughout India is known as the *khair* or *katha.* Rice draws attention to the fact that the *khadira* tree is in the Vedas used as a simile for strength. In the paper above cited Major D. Prain, M.A., M.B., LL.D., I.M.S., has rendered valuable service by establishing the characteristics and respective areas of distribution, of the three forms of this plant. He regards these as but varieties of one species; whereas Roxburgh treated them as separate species. Major Prain's opinions and conclusions may be briefly set forth as follows:—

PALE CATECHU. Botanical varieties.

(*α*) **A. CATECHU,** *Willd. (proper). Calyx petals and rachis with spreading hairs.*—This is the most Northern form having been recorded as met with in Hazara, Kashmir, Simla, Kangra, Garhwal, Mussoorie, Central India, Behar and South to Ganjam. But it has never been found in the Eastern Himalaya nor in Assam, and it has been only once reported as met with in Burma, *viz.*, at Pegu where, according to Kurz, it is called *sha.* This is, therefore, the *kath*-yielding form of Kumaon—the *PALE CUTCH* as it is sometimes called.

PEGU CUTCH.

(*β*) **A. CATECHUOIDES,** *Benth.—This may be recognised as having the calyx and petals glabrous but the rachis puberulous.* It is met with in Bengal from Monghir and Patna to Sikkim, Assam and Burma. Though quite common in Pegu and Prome this has not as yet been collected in the Shan Hills nor in Upper Burma to the North of Ava. This is, therefore, the cutch-yielding form of Burma—and "*PEGU CUTCH*" is the chief commercial form of the extract.

MADRAS AND BOMBAY CUTCH.

(*γ*) **A. SUNDRA,** *DC.*—Major Prain *distinguishes this variety by the circumstance that the calyx, petals and rachis are all glabrous.* It is the Southern and Western plant and affords the cutch of Madras and Bombay Presidencies. Is very common from Coimbatore Northwards to the Deccan, Kanara and the Konkan and has been recorded so far to the North-West as at Kathiawar and in Rajputana also to the North-East in Burma, at Segain, Mandalay and the Shan Hills. It is the *lál-khair* (*RED CATECHU*), the *nalla-sandra* (or simply *sandr*, or as Sir Walter Elliot renders it *chandra*), the *kati, kute, kachu, kempu, shemi, karungalli, baga, banni,* etc.

Properties and Uses.

These three forms are said to be practically identical in their properties and uses. They certainly all yield a GUM, an astringent EXTRACT and a useful TIMBER. How far this general statement can however be regarded as correct will be seen from the remarks that follow, in which it will be noted a contention is put forth that the extracts at least differ from each other.

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ACACIA Catechu.

History of the Extract.

CUTCH.

1.—Gum.

This is of a pale yellow colour and often occurs in tears one inch in diameter. It is sweet to the taste, is soluble in water, forms a strong pale-coloured mucilage and is not precipitated by neutral acetate of lead, but gelatinises with basic acetate of lead, ferric chloride and borax. It freely reduces Fehling's solution. It is a better substitute for the *TRUE GUM ARABIC* than is *babul* gum. And, as already stated, much of the superior qualities of *INDIAN GUM ARABIC* are very possibly obtained from this species (more especially variety *Sundra*) and the modern exports from the Malabar Coast, such as from Tuticorin, are in all probability mainly derived from that plant.

TIMBER.

2.—The Timber.

Sapwood yellowish white, heartwood either dark or light red, extremely hard. It seasons well, takes a fine polish and is extremely durable. It is used for all kinds of agricultural implements, bows, spears, sword-handles and wheel-wright work. It is in Burma employed for house posts and very largely as fuel for the steamers of the Irrawaddy Flotilla. The FUEL of dead *khair* is much valued by goldsmiths. In Northern India cutch wood is made into CHARCOAL and is regarded as one of the best woods for that purpose. It has been pronounced good for railway sleepers. A cubic foot weighs 70 lbs. But it is as the material from which CUTCH extract is prepared that the wood of this plant attains its greatest value.

Fuel.

Charcoal.

CUTCH.

3.—The Extract Cutch or Catechu.

It is not proposed to deal with this substance very elaborately in the present review. The article in the *Dictionary of Economic Products* amplified as it has been by *The Agricultural Ledger No. 1 of 1895, No. 2 of 1896* and *No. 35 of 1896*, contains practically all that is known. The reader is referred to these publications and the remarks that follow must, therefore, be accepted as a mere abstract intended more especially to represent the aspects of commercial interest :—

COMMERCIAL FORMS.

History.—Although the wood of *A. Sundra* affords *CATECHU* or *CUTCH*, it is much less frequently used for that purpose than either of the other two forms of the species. It is in all probability the plant that affords the cutch of Dharwar, of the South Konkan, of Khandesh, of Surat and of Baroda. The cutch of Pegu is derived from *A. Catechuoides* and the *kath* of Kumaon, the cutch of Dehra Dun, Gonda and Chutia Nagpur from *A. Catechu*. It remains to be seen how far the peculiarities of these trees account for the different properties of the extracts. Hitherto the possibility of these being dependent on the species (or variety) of plant, has escaped attention. But it may be mentioned as a curious circumstance, very possibly connected with *A. Sundre, viz.*, that one of the earliest European writers, Barbosa

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(1516 A.D.), speaks of *cacho* as exported from Cambay to Malacca. The name *cacho* would seem to be simply the Kanarese *kachu* and very possibly gave origin to the modern Latin name *Catechu*. In 1574 Garcia de Orta gave a complete account of the plant and of the manufacture of the extract, under its Tamil name of *kati* (*cate*) a word which by some authors gave the first half of the name *Catechu*, the second being derived from *chuana*, to distill. Although the earliest European authors saw the extract being prepared from *A. Sundra*, it is probable that the manufacture in Pegu is quite as ancient, if not more so. But it was not until the 17th century that *Catechu* attracted the attention of Europe. It was then supposed to be a natural earth and as it reached Europe by way of Japan it received the name of *TERRA JAPONICA*. About the same time *GAMBIER* also found its way to Europe and was indiscriminately with *Catechu* designated *TERRA JAPONICA*. Cleger exploded the mineral notion of these substances by republishing in 1685 Garcia de Orta's account of the preparation of the extract. He affirmed that the best quality came from Pegu, other sorts from Surat, Malabar, Bengal and Ceylon.

DARK CATECHU.

Exported from Cambay.

Origin of Name.

Terra Japonica.

Gambier: First Mention of Pegu Cutch.

Forms of Catechu.—There are said to be three forms of this substance (1) *DARK CATECHU* or *CUTCH*, chiefly used for industrial purposes: (2) Indian *PALE CATECHU* or *KATH*—a crystalline substance eaten in *pán* or used medicinally: and (3) *KEERSAL (KIRSAL)*, a crystalline substance found imbedded in the wood, much after the same fashion as *BARUS CAMPHOR*.

Forms of Cutch.

The following particulars may be given regarding the manufacture of the two first mentioned extracts :—

1. Dark Catechu or Pegu Cutch.—Three men generally work together: one cuts down the trees and drives the cattle that drag these to the site of the furnace: the second clears off the sap wood and cuts the heart-wood up into the little chips required by the third man who attends to the furnaces and boilers. The chips are packed into three to four gallon earthen pots which are then filled up with water, and the whole boiled for 12 hours. When the water is boiled down to one-half the chips are taken out, and the liquid of 20 to 25 pots is gradually poured into a large iron pan or cauldron, and again boiled and stirred and fresh added from the earthen pots until the fluid attains the consistency of syrup. The cauldron is then taken off the fire and the contents stirred continuously with a wooden paddle for four hours or more till the mass cools and can be handled. It is then taken out and spread on leaves arranged within a wooden frame like a brick mould. It is left over night and in the morning is dry and ready to be cut up into pieces for the market. It might then be described as a brick of cutch weighing 36 to 44 lbs.

DARK CATECHU OR PEGU CUTCH. Three Men work together.

Chips boiled in Earthen Pots.

Iron Cauldrons.

Stirring.

Wooden Mould.

ACACIA Catechu.

Manufacture of Cutch.

CUTCH.

After Treatment.

The chips are sometimes boiled down a second time, but as a rule very little is extracted by this farther boiling. Much difference of opinion prevails as to the necessity of beating the liquid after the cauldron is taken off the fire. Some manufacturers are satisfied with half-an-hour, others give it as much as four or five hours.

Season of Working.

Cutch manufacture takes place from the 1st June to 31st March, but the months of December to March inclusive are those of most energetic operations. The produce of each cauldron is approximately as stated 36 to 44 lbs. a day, but the total yield during the season cannot be accurately determined since much depends on the quality of the trees, their proximity to the boiling place and above all the working days of the season. The proceeds of one cauldron may be 2,000 lbs. or it may exceed 6,000 lbs. As to yield of cutch to weight of heartwood, it is believed that a ton of wood might be taken as yielding 250 to 300 lbs. of cutch.

Yield.

Other Forms of Cutch.

On the Western side of India as at Kanara, Dharwar, Khandesh, Surat and Baroda and to some extent in Chutia Nagpur in Bengal, in Dehra Dun and at Gonda in Oudh, dark coloured cutch is also prepared by a process that only differs in minor details from that briefly described in connection with Pegu. The industry in these regions is on a much smaller scale, and the appliances correspondingly less perfect, but the principle involved is the same. In Guzerat, as a rule, the trees are not felled, but the larger branches are simply lopped off, and these are cut up and boiled down into cutch. The article as met with in the market, from these localities, differs, however, materially in external appearance and shape from *PEGU CUTCH*. It occurs in small cubes, flat cakes or rounded balls, and is of a redder colour and more opaque fracture and less shining; but, as already hinted, how far the chemical property and industrial value is influenced by the circumstance that the trees employed are botanically different varieties, remains to be investigated in the future. As already explained the plant used for *PEGU CUTCH* is *var. Catechuoides*: for Western and Southern Cutch, *var. Sundra:* and for Northern cutch, *var. Catechu.* The influence of the method of manufacture more especially the use of iron cauldrons will be discussed in a further paragraph.

PALE CATECHU.

Method of Preparation.

2. Pale Catechu or Kath.—This is the restricted name, given in Northern India, to a grey crystalline substance prepared from a concentrated decoction of the wood of *var. Catechu* by placing in it a few twigs and allowing the decoction to cool. The twigs are removed and the crystalline substance found adhering to them is collected, and pressed into large irregular cubes. Whether the liquid is rejected or is afterwards boiled down to produce a poor quality of dark catechu or cutch has curiously enough not been recorded.

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KUMAON KATH.

The cubes of grey crystalline substance is the *kath* which is eaten by the Natives in their *pán* and which imparts with lime a red colour to the lips. It is apparently hardly ever exported to Europe and the name *kath*, while chiefly applied to it, is in some parts of India unfortunately also given to cutch. *Kath* and Cutch have by Europeans been mistaken for the same substance, but the former is much purer chemically than the latter, and it may be owing to the fact of cutch being the form exported to Europe, that catechu has lost the former position it held as an astringent MEDICINE. It seems probable that the preparation of *kath* may be a secondary process from the cutch, since its direct preparation from the original decoction has only been observed at Kumaon, although the substance is universally used in *pán* all over India. This subject deserves to be thoroughly investigated, and the merits of *kath* and its process of preparation made known. In a further paragraph will be found an abstract of recent investigations that have a bearing on the issue here raised.

Medicinal Form. Secondary Manufacture.

The dark and the pale forms of *khadira* were both well known to the Sanskrit writers, but in later times they seem to have been confused with each other. The process of preparation of *katha* or *kath* was described by Madden and no more recent observer appears to have watched the manufacture with the same interest. "One portion of the *khairis*, wrote Madden, is constantly employed in cutting down the best trees, and for these they have to search far in the jungles; only those with an abundance of red heartwood will answer. This is chopped into slices a few inches square. Under two large sheds are the furnaces—shallow, and with a slight convex clay roof pierced for twenty ordinary-sized earthen pots. This operation takes place in about an hour and half. The liquor resembles thin light port, and the *katha* crystallizes on leaves and twigs thrown into it for that purpose. Each pot yields about a seer of an ashy white colour. The work is carried on for twenty out of the twenty-four hours by relays of women and children; the men merely preparing the wood, which, after being exhausted, is made use of as fuel."

Madden's Account.

3. *Keersal or Khersal.*—From the wood of *Acacia Catechu* is occasionally obtained a pale crystalline substance known as *khersal*. The woodmen, when cutting up the timber for fuel, sometimes come across this substance and carefully collect it, since it is much valued as a medicine by the Hindus, and fetches a high price. Dr. Dymock (*Mat. Med., Western Ind., 232*) says of it:—

KHERSAL.

"*Keersal* or catechuic acid is obtained from cavities in the wood and occurs in small irregular fragments like little bits of very pale catechu mixed with chips of reddish wood." "In the forests near Bariya, Guzerat, this substance is collected and is regarded as a valuable cure for coughs." (*Bom. Gaz., VI., 13*). It appears to be

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ACACIA Catechu.

Recent Investigations.

CUTCH.

procured from any of the three varieties of *A. Catechu* though in the passages just quoted the reference is of course to *var. Sundra.*

Dr. Warth's Investigations.

Recent Investigation.—*The Agricultural Ledger* (*No. 1 of 1895*) records Dr. Warth's experiments and results in the manufacture of cutch and the correspondence that ensued on his recommendation for the establishment of central factories under Government control. Dr. Warth showed that the Native system was wasteful and destructive, more especially through the use of iron cauldrons. He explained that the active principle of cutch was the tannin known as *Catechu-tannin.* This forms a greenish-brown compound with ferric salts. There is also present, however, another substance known as *Catechin* and this is the active principle in *kath* or the edible form of cutch. Catechin is, however, easily changed into tannin. It is soluble in hot water but practically insoluble in cold water, while Catechu-tannin is completely soluble in cold water. By this simple circumstance Warth proposed that catechin should be invariably separated from the Catechu-tannin and sold by itself, but he showed that it was essential that this should be accomplished by a rapid process and in concentrated solutions. Etti had previously pointed out these peculiarities but Warth gave them a practical value. The concentrated decoction is by him recommended to be set aside for five days, to allow of the formation of the crystalline Catechin. Cold water is then added and the solution filtered and the filtrate again boiled down to form Cutch free from Catechin. It seems probable that by some such process *kath* may be regularly manufactured by the drug-dealers of India, since the Kumaon supply could hardly suffice to meet the Indian consumption.

Catechu-tannin and Catechin.

Separation of.

Recent investigations.

Preparation of Kath.

Warth then demonstrated the injurious action of iron on Catechin and urged that copper cauldrons should be invariably used. Warth's observation that wood spotted with white deposits is richest in a Catechin and that such wood is more prevalent in Oudh than in Burma, confirms a wide-spread Native opinion and probably points to something peculiar in the variety of plant grown in Oudh as compared with that of Burma.

Wood Spotted White.

The inquiry was next prosecuted by Dr. Leather, Agricultural Chemist to the Government of India. His Assistant, Mr. Collins, furnished a most instructive table of analyses in which he showed that commercial valuations rarely coincided with percentage of Catechu-tannin and Catechin (more especially of the latter) but was dependent mainly upon the appearance of the extract. So far as the tanner is concerned the complete absence of Catechin might be said to be a recommendation. Dr. Leather dealt in a most interesting manner with the best methods of cutting up the timber, with the

Dr. Leather's Researches.

Commercial Valuation

Important Considerations.

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effect of different kinds of water, the quantity of water required, and the time which was essential to boil the wood. Briefly he showed that it would be more economical to reduce the wood to shavings by the carpenter's plane rather than to cut it into chips as at present. When reduced to shavings the yield of Catechu-tannin and of Catechin was much higher than with chips; the quantity of water to weight of wood could be reduced from 20 to 10 or even less; and the duration of boiling might be reduced from 12 hours to half an hour. All these circumstances indicate not only vast financial economies but the production of a superior quality of extract owing to the smaller amount of boiling that is necessary. The separation of white Catechu (or Catechin) from Cutch (or Catechu-tannin) might be made a commercial success if attempted from an extract prepared in the manner indicated by Dr. Leather. CUTCH DYES. Great Economies.

Dyes.—In *The Agricultural Ledger* (*No. 35 of 1896*) will be found the results of Professor J. J. Hummel's and Mr. Reginald B. Brown's chemical investigations into the dyeing properties of Catechu-tannin and Catechin. Briefly they have demonstrated that both these substances may under certain circumstances be used as dyes. But the reader should consult the publication named and purely chemical works for other details regarding these compounds. The present purpose is to convey the facts of commercial importance and the bearings of recent research on possible developments of the Cutch industry. CUTCH DYES.

Production and Trade in Cutch.—Trustworthy returns are not available regarding the production of Cutch in India. The trade is very largely in the hands of small manufacturers and dealers. As a rule the right to work the Cutch forests, belonging to Government, is granted by license and is sold by auction or tender. The period for which the licenses hold good is usually four months. *Commercial Circular No. 11* of 1896 gives certain particulars of interest regarding the Burma trade. It is calculated that on the average 80 Cutch trees are used per cauldron and as the average price paid for the cauldrons comes to R225, the average price obtained per tree comes to R2-13. But each tree would yield about 25 cubic feet, say ½ ton, so that the price obtained is equivalent to R5-10 per ton, or nearly as much as is usually got from local traders for undersized teak logs. TRADE IN CUTCH.

It would seem that the Burma production averages from 130,000 to 150,000 cwt. a year; the South Indian perhaps 1,000 cwt.: the Bombay perhaps half that quantity, and it is probable that Bengal and the North-Western Provinces yield between them about 20,000 cwt. This conception of the probable annual production is inferred very largely from the returns of Foreign, Coasting and Internal Trade, rather than from actual statistics of production and consequently it Total Production.

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ACACIA Catechu.

Trade in Cutch.

TRADE IN CUTCH.

Fluctuations.

ignores local consumption. Thus, for example, the total exports to foreign countries were 183,729 cwt. valued at R36,96,106 in 1895-96; 122,082 cwt. in 1896-97; 97,187 cwt. in 1897-98; 61,669 cwt. in 1898-99; but it rose again to 127,815 cwt. valued at R24,70,422 in 1899-1900, and in 1900-1901 fell to 101,995 cwts., valued at R18,91,369. Of course the bulk of these transactions are from Burma. For example, taking the last-mentioned total exports, Burma furnished 99,729 cwt., Bengal 2,202 cwt., Madras 57 cwt., and Bombay with Sind, 7 cwt. The Bengal trade seems for some years to have declined and direct shipments from Burma to have increased. The United Kingdom, the United States, the Straits Settlements and Egypt are the countries to which the largest consignments are made. The United Kingdom takes from 70 to 80 per cent. of the total annual supply.

Coastwise.

Of the coastwise traffic Bengal (Calcutta) is the most important receiving centre and Burma the most important exporting. In 1895-96, Bengal received 35,079 cwt., but that traffic seems to have declined seriously and last year was less than half the quantity named. The Rail, Road and River borne trade shows Bengal Province as the most important receiving centre and mainly from the town of Calcutta. While the North-Western Provinces might be called the most important exporting centre, the major portion going to Bombay town and presidency.

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G. I. C. P. O.—No. 588 R. & A.—12-8-1902.—2,230.—C. M W.

THE

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(Mineral Product Series, No. 20.)

THE AGRICULTURAL LEDGER.

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ALKALIS.

(EARTHS, ASHES, ALKALOIDS, ETC.)

[*Dictionary of Economic Products, Vol. I.*, A. 758.]

ALKALIS, ALKALINE EARTHS, ALKALINE ASHES, ALKALOIDS, ETC.

A Review of existing information in which are brought out the chief commercial facts regarding these substances. By GEORGE WATT, M.B., C.M., F.L.S., C.I.E.

ALKALIS.

It would be beyond the scope of this review to deal with the substances indicated by the heading given to this article in any pretention to completeness, but it might almost be said that the industrial progress of a country can be judged of by the extent to which it produces the *Alkalis* required by its own industries.

Classification.

In its restricted sense the term *Alkali* might be said to denote *ammonia, potash, soda, Lithia*—the *Alkalis* proper. But in a wider signification it embraces the *Alkaline Earths, viz.*, the hydrates of the metals *barium, calcium* and *strontium.* These all possess to a certain extent the properties usually attributed to the alkalis. So in a like manner the *Alkaline Ashes* are very largely crude alkalis and even alkaline earths obtained by burning certain plants. Lastly the *Alkaloids* such as *aconitine, morphine, quinine,* etc., have been described as the *Organic Alkalis.*

Distinctive Features.

The distinctive features of these compounds may be said to be their solubility in water, their neutralisation of acids, their corrosion of animal and vegetable substances and lastly their property of changing or inverting vegetable colours, such as litmus.

In all fairness it may be said of India that it does not possess any industry (pursued on modern scientific methods) for the production or refinement of the alkalis, alkaline earths and their salts.

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ALKALIS.

Alkalis, Alkaline Earths, Alkaline Ashes, etc.

MATERIALS HERE DEALT WITH.

Such manufactures as do exist (if common salt be for the moment left out of consideration) are a century behind the times and consist mainly in the production of saltpetre, pearl-ash, barilla and the like.

For convenience the following key may be here given to the substances dealt with in the remarks that follow :—

AMMONIA.

1. AMMONIA and its SALTS ; (*Dict. Econ. Prod., Vol. I., 219-20*).

Not manufactured in India.

This alkali is in Europe and America very largely prepared from "gas liquor" or "bone liquor" or from "volcanic salts." It is not manufactured to any appreciable extent in this country, for the simple season that none of the crude materials named are to be had in sufficient abundance. The chief preparations and salts are (*a*)

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Alkalis, Alkaline Earths, Alkaline Ashes, etc. (*G. Watt.*) ALKALIS

AMMONIA.

Liquor Ammonia used as medicine, as a chemical and as a solvent for resins and for certain active vegetable principles, thus forming varnishes and ammoniated tinctures. Of the latter class may be mentioned the "Essence of Ginger," employed in the manufacture of gingerade and ginger beer; of the former the hatter's varnish, which consists of shellac dissolved in ammonia and alcohol. *Essence of ginger.* *Hatter's varnish.*

The salts are (*b*) the **Chloride** (*Narasára* or *Nausadár*) of importance as a material from which to manufacture other salts of ammonia, also essential in galvanizing, and in galvanic batteries and as an alkaline flux. (*c*) The **Sulphate** which is largely employed as a manure. (*d*) The **Carbonate, Sulphide, Oxalate, Nitrate, Phosphate,** and **Bromide,** all of which take important places in the arts and industries of every country and may be said to be entirely imported by India. *The Salts.*

2. POTASSIUM or POTASH: (*Dict. Econ. Prod., Vol. I., page 167; II., 152-4; VI., Part I., 332*).

POTASSIUM.

(A) **CARBONATE OF POTASH.**—This is the chief source of *CAUSTIC POTASH* and the two compounds may, therefore, be dealt with collectively in this place. The carbonate in its crude form is often called *POTASHES* or *PEARL-ASHES* and in Bengali *Sarjika*, in Hindustani *Jon-khár*, or *ivak-chár*, and in Sanskrit *Yavakshára*. Of the other provincial names the following may be quoted :—*jhar-ka-namak, jhadicha-mitha, mara-vuppu, manu-vuppu, búdide-vuppu, káram*, etc. PEARL-ASH. *Vernacular names.*

Sources.—Formerly the European supply of the crude material from which this substance is manufactured, was very largely the *PEARL-ASH* or *WOOD-ASH* obtained from America, Canada and Russia, etc. While the production of pearl-ash has steadily declined with the advance of the traffic in more scientific and less wasteful materials, the imports into Europe of pearl-ash have not been entirely discontinued. Caustic potash is usually manufactured from the carbonate and this is procured :—(*a*) From the ashes of plants. (*b*) From the soil (due to the disintegration of felspar and other silicates and the ultimate combination of their potash with carbonic acid), also numerous methods patented for the accomplishment of this same result artificially. (*c*) From the sulphate of potassium, produced by the decomposition of the chloride through the agency of sulphuric acid followed by fusion of the resulting sulphate with limestone and charcoal, in other words a process almost identical with the Le Blanc method of treating soda. (*d*) From *SUINT* or the wool of sheep impregnated with the sweat that exuded from the bodies of the animals. (*e*) Beet-root *VINASSE*. *Sources.* *Conf. with Barilla.* *Manufacture of.*

ALKALIS. ***Alkalis, Alkaline Earths, Alkaline Ashes, etc.***

PEARL-ASH.

Of plants it may in general terms be said that herbaceous annuals contain more pearl-ash than woody arborescent plants, but even of the same plant the succulent young parts are more highly charged than mature tissues. Of different plants, 1,000 parts of pine contain on an average only 0·45 parts of potash, oaks 0·75, vine shoots 5·50, ordinary straw 5·8, ferns from 4·25 to 6·26, Indian cornstalks 17·5, nettles 25·03, wheat straw before earing 47·0, wormwood 73·0, and beet about the same amount. These facts naturally suggest the plants best suited for the preparation of pearl-ash, and the immense development within recent years of the beet-sugar industry at once awakened an interest in carbonate of potash as a by-product that might supplement the returns of beet cultivation. This has been actually turned to account.

Yield in various plants.

Carbonate of Potash—A by-product in Beet-sugar.

PEARL-ASH. Plants used in India.

Indian Sources of Pearl-ash.—The following may be given as the principal plants employed in India for the preparation of pearl-ash:—

Achyranthes aspera.
Adhatoda Vasica.
Alstonia scholaris.
Amaranthus spinosa.
Bamboo ash.
Borassus flabellifer.
Butea frondosa.
Cæsalpinia Bonducella.
Calotropis gigantea.
Cassia Fistula.
Cedrus Deodara.
Erythrina indica.
Euphorbia neriifolia.
Euphorbia Tirucalli.
Gmelina arborea.
Holarrhena antidysenterica.
Hordeum vulgare.
Indigofera tintoria.
Luffa ægyptiaca.
Musa sapientum.
Nerium odorum.
Pennisetum typhoideum.
Plumbago zeylanica.
Pongamia glabra.
Shorea robusta.
Stereospermum suaveolens.
Symplocos racemosa.
Terminalia bellerica.
Vallaris Heynii.
Vitex Negundo.

Crude Indian Alkalis.

The crude ashes obtained from the above and such like plants are the chief sources of the potash salts employed by the people of India in their arts, sciences and medicine. According to Professor Giacosa the ash of *Adhatoda Vasica* is exceptionally rich in potash.

SOAP. GLASS. DYES.

Uses.—In Europe carbonate of potash is largely in demand for the manufacture of certain soaps, after having been converted into the caustic. It is also essential in the formation of potash-glass and enters into many tinctorial and textile processes, such as the dyeing of Turkey red and of Arnotto *(Bixa Orellana). In India* it would be almost impossible to overestimate the extent to which a crude carbonate of potash is employed by the people of this country. A better selection of plants or improvements in the methods pursued for the production of pearl-ash are subjects, therefore, of no small importance.

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Alkalis, Alkaline Earths, Alkaline Ashes, etc. (G. Watt.) ALKALIS.

PEARL-ASH.

It may accordingly be remarked that it is surprising that while immense tracts of mountainous land are in India injuriously covered with various species of wormwood *(Artemesia),* except as a manure used locally, the ashes of these plants are not apparently utilized by the people. From the high percentage of carbonate of potash which they contain, the preparation of pearl-ash from the wormwoods might be confidently recommended to the poorer inhabitants of the temperate regions of India as a useful new industry.

A useful New Industry.

MANURE.

Much attention has recently been given both in the United States and in Great Britain to the value of wood-ashes as a manure. Potash is admittedly an essential constituent in plant-food, and although the amount present in the ash of different plants varies greatly, the importance of potash to practically all cultivated plants cannot be denied. It is, as already explained, more abundant in the actively growing parts than in the matured stems, hence its intimate relation to life and its necessity as an article of plant-food. Potash is present in all clayey soils but it need not necessarily exist, even in such soils, in a condition available for the plant. Marshy land and land with much sand may be said to require potash fertilizers.

Presence in the soil.

Rabby seed-beds.

In Bombay, especially in the rainy tracts, the system prevails of *rabbing,* as it is called, the seed-beds. This consists in burying brush-wood, boughs of trees, cow-dung, etc., etc., under a thin layer of soil, then firing the mass. In this way the soil becomes highly charged with wood-ashes, the most important constituent of which is doubtless potash. It is found that the finer qualities of rice can alone be grown when the seed has been previously germinated on *rab*-beds and later on transplanted to the fields. It would be well, in connection with the subject of potash as a manure, for the reader to consult Dr. J. W. Leather's admirable papers on INDIAN MANURES, in *The Agricultural Ledger No. 8 of 1897 and* INDIAN SOILS *l. c., No. 2 of 1898.*

SALTPETRE.

(B) **POTASSIUM NITRATE.** (*Dict. of Econ. Prod., Vol. VI., Pt. II, 431-47.*)

Vernacular Names.

NITRATE of *POTASH, NITRE* or *SALTPETRE,* according to U. C. Dutt (*Mat. Med. of the Hindus*), was unknown to the ancient Sanskrit authors and its name *Soráka* which occurs in the more recent publications, is but "Sanskritized from the vernacular *Sorá,* a term of foreign origin" He then adds "The manufacture of nitre was, therefore, most probably introduced into India after the adoption of gunpowder as an implement of warfare." But as opposed to this view it seems fairly certain the Natives of India had fireworks long before the invention of guns. Saltpetre is known in the vernaculars as follows :—*Suriakhar, shorá, shora-kalmi,* (refined), *potti-luppu,*

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pet-luppu, veti-luppa, sandawa, yan-zin, etc. *Shorá* appears to be its Persian name.

Localities of Production.

Occurence and Production.—The saltpetre of Indian commerce is derived mainly from Behár (chiefly Gya, Tirhut, Saran and Champáran), to a much less extent from the United Provinces of Agra and Oudh (such as Cawnpore, Ghâzipur, Allahábád and Benáres) with still smaller quantities from the Pánjáb, Kashmir, Central India (Bhind and Jwargarh) Bombay, Madrás (such as Coimbatore, Salem, Kistna, Nellore, Trichinopoly, Madura) and lastly from Burma (Tenasserim).

Presence in the soil.

It occurs as a natural efflorescence on the surface of the ground mixed with chlorides of potassium and sodium, nitrate of lime, and sulphate of soda. But the saltpetre lies as it were in patches being more abundant according as carbonate of lime and sand predominate. (See Stevenson's *Paper (1833) reprinted in Dictionary of Economic Products.*) Mr. F. Ashton in an interesting report on salt (sodium chloride) in *The Agricultural Ledger, No. 13 of 1900,* alludes incidentally to saltpetre in the following passage :—

Nitrating Ferments.

"Owing to the presence of potash and decaying organic matter being more abundant in towns and villages than elsewhere, the nitrating ferments show the greatest activity in the soil of such localities and the profitable manufacture of saltpetre becomes possible and is carried on. A proportion of sodic chloride is always present in the nitrous soil which is utilized, and this when separated from the saltpetre with which it is in mechanical admixture is termed "Saltpetre Salt." When first obtained from nitrous soil, saltpetre is in an impure state, owing to the presence of earthy matter and chloride of sodium and other salts, and it is termed *"CRUDE SALTPETRE."* This crude substance has to be purified before it is fit for export, earthy matter being removed and foreign salts (sodic chloride particularly) eliminated as much as possible. This purification is effected in refineries, which are scattered over Northern India and Behár, and there are also a few in Calcutta. During 1898-1899, there were 36,997 crude saltpetre factories and 570 refineries in Northern India and Behár, and 13 refineries in Calcutta. The refineries utilised 722,714 cwts. of crude saltpetre and produced 408,335 cwts. of the refined substance in a condition fit for export." Stevenson, Baden Powell, and many other writers have recorded the circumstance that saltpetre forms in greatest abundance on ruined houses of deserted villages or on the mud-walls of inhabited dwellings, but the action of a fermentative geim in bringing about the formation of nitre is one of the modern discoveries that is engaging attention in India.

Crude Saltpetre.

REFINERIES.

Formation Near Human Dwellings.

Uses of Nitre.—It is hardly necessary to enumerate these as they are so well known. It is an important ingredient in

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SALTPETRE.

Gunpowder.

Gunpowder, owing to the large volume of oxygen which it contains, the ease with which it parts with its oxygen and the fact that it does not readily absorb moisture from the air. On the other hand sodium nitrate is preferred to potassium nitrate for the manufacture of *nitric acid* both because it is cheaper and yields about 7 per cent. more acid. In India saltpetre is used as an *assistant* with certain animal dyes such as lac and cochineal. In *medicine* it is sometimes prescribed because of its diaphoretic properties. Its merits as an *antiseptic* in preserving fish and meat are well known. As *manure* it is much appreciated, especially for wheat and tobacco (*see The Agricultural Ledger No. 8 of 1897, page 33*) and in India it is at times employed as a *flux* in glass-making.

Nitric acid.

Assistant Antiseptic Manure.

Trade

History of Saltpetre.

Trade and History.—In view of the observations already offered, regarding the backwardness of India in the production of the alkalis required for her arts and industries, no study could be more instructive than the history of saltpetre. It might be said that the rise of the East India Company into a position of political importance was intimately associated with the early export trade in Indian saltpetre. The Company were bound down by treaty to supply to Great Britain annually, in times of peace, with a fixed quantity (500 tons), before they were free to offer any for sale to other nations; and they were at the same time prohibted from cornering the market, in times of war, by a maximum rate being fixed for the British supply. But saltpetre was essentially a speculative article since the price would suddenly rise, on the slightest suspicion of war, and fall as quickly and abnormally with the report of peace. For a century or more, however, saltpetre and sugar were the exports most highly valued as "dead weights" for ships carrying silk, silk-goods, muslins and other expensive but light goods. This unsatisfactory state of affairs continued until chemical science furnished Europe and America with new, cheaper and more regular sources of supply. In 1846 the discovery was made that Chilian saltpetre (sodium nitrate) could be converted into potassium nitrate, thus rendering a practically limitless supply available for the demands of commerce. It was, therefore, only what might have been anticipated, that interest in the natural salt of India—a salt obtained by a crude process and one which was constantly liable to adulteration, through the impecuniosity of the manufacturers or the criminality of the traders, should greatly decrease or at all events should cease to expand when brought face to face with scientific and accurate manufacture. In support of this contention I would mention that the exports from America of Chilian saltpetre were in 1830 only 935 tons but 60 years later they were 1,033,100 tons valued at £ 8,000,000, of which Germany took in 1890, 344,209 tons and in 1899, 531,034 tons. But the still cheaper

Political Aspects.

Dead weight Cargo.

Crude versus Pure Salt.

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production from potassium chloride enabled Germany to not only discontinue her demands on India and Chili for saltpetre but to commence to export that salt to all parts of the world.

Half-Century's Traffic.

The Indian exports of saltpetre from Calcutta were in 1845 a little under $\frac{1}{2}$ million cwts., valued at 35 lakhs of rupees. During the succeeding half century they fluctuated but marked rather a downward than forward course, so that in 1894-95 they stood at 325,985 cwts. valued at Rs. 41,13,650. In addition to new sources of supply disturbing the markets, discoveries have been made that have curtailed many of the older outlets for saltpetre such as the subtitution of new explosives for gunpowder and of frozen for preserved meats, etc. But to conclude this brief review it may be said that during the past five years (1896-97 to 1900-1901) the exports have shown considerable fluctuation and if anything have slightly improved, the average of the years in question being 411,053 cwts. The actual exports of last year were 346,388 cwts. valued at Rs. 33,95,324, of which the United Kingdom took 100,863 cwts., the United States 75,462 cwts., China (Hongkong) 104,144 cwts., the balance 65,919 cwts., to all other countries.

Disturbing Influences.

Recent Transactions.

OTHER POTASSIUM SALTS. Bicarbonate Oxydising Agent. Chlorate.

(C) **OTHER POTASSIUM SALTS.**—In addition to the compounds of potash already indicated the following may be mentioned :—(1) **Bicarbonate,** chiefly used medicinally as a diuretic and antacid. (2) The **Chlorate**—a salt which readily parts with its oxygen and on that account is utilized as an oxydising agent in calico-printing. Together with phosphorus it is employed in the manufacture of matches and in the production of fireworks and detonators. (3) The **Chloride**—this closely resembles ordinary (or table) salt and similarly is often found native either pure or in combination with other metallic chlorides, the mixture being known as *POTASSIC MINERALS.* It may also be obtained (and used formerly to be largely manufactured and is so to some extent at the present day) from the ashes of sea-weeds or *KELP.* The chloride is also procured from brine-springs such as those in the South of France. (4) **Bichromate of Potash** is a salt of considerable importance, owing to its being extensively employed in calico-printing and dyeing as also in fixing catechu. (5) **Cyanide Ferricyanide** and **Ferrocyanide** are salts of potassium that each hold important places in the arts and industries. Cyanide is essential in photography, in electro-gilding and plating. Ferrocyanide is employed in the preparation of the ferricyanide and both salts are practically indispensable in the dyeing industry of Europe. (6) **Iodide of Potassium, Oxalate of Potassium** also (the **Binoxalate** or "*SALT OF SORREL*" or "*SALTS OF LEMON*"), the **Sulphate of**

Matches. Fireworks. Chloride.

Potassic Minerals.

Kelp.

Bichromate.

Catechu.

Cyanide Ferricyanide and Ferrocyanide. Electro-gilding.

Dyeing. Iodide Oxalate Binoxalates.

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Potassium a very important manure (and the *BISULPHATE*) and the **Tartrate of Potassium** (or "Cream of Tartar," are all salts of the greatest importance in the industries.

OTHER POTASSIUM SALTS.

Bisulphate Tartrate.

3. SODIUM AND ITS COMPOUNDS. (*Dict. Econ. Prod. Vol. II., 154.*)

SODIUM.

Definition.

The term soda strictly speaking denotes the oxides of the metal but it is also used for the hydrate and the carbonate. The last mentioned is not only the most important commercially but it is the compound from which the majority of the other soda salts are made or can be made and, therefore, it may be dealt with in greatest detail.

CARBONATE OF SODA.

(A) **CARBONATE OF SODA.**—This important salt exists in nature and is as a rule the most abundant and, from the point of view of the agriculturists, the most objectionable ingredient of the soluble sodium salts found in the soil. This subject will be dealt with in a further paragraph under the heading of *REH* deposits (page 117). It may be here observed that from such deposits carbonate of soda can be isolated and purified commercially or a crude mixed salt can be made that may be utilized in the manufacture of other alkalis or in the glass, soap and other trades. Sodium carbonate in an even purer state may be obtained from the brine of certain lakes such as the Lonar in Berar.

Sources.

From Plants, (Kelp and Barilla).

Manufacture from Kelp.—In Europe some few years ago a large trade used to exist in the separation of sodium carbonate from calcined sea-weeds—*KELP*—or salt-worts—*BARILLA.* Indeed to this day it may be said that *SALSOLA SODA* is still regularly cultivated both in France and Spain because of the large amount and fine quality of soda obtained from its ashes. And it was the loss of their regular supplies of *BARILLA,* during the wars with Spain, that compelled the French people to seek for new sources of barilla and finally led to Le Blanc taking out a patent in 1792, for the artificial manufacture of carbonate of soda from common salt. The calcination of seaweeds is pursued as a rule for the purpose of obtaining potash rather than soda and at the present day "kelp" is much more frequently spoken of as the source of iodine than of either of the alkalis named.

Origin of French Discovery.

Iodine.

From Common Salt.

Manufacture from Sea Salt.—The artificial manufacture of soda has within the past century attained such perfections and proportions as to have almost revolutionised the chemical works and industries of Europe. By the Le Blanc process common salt is reduced by means of sulphuric acid to sulphate of soda. It is next converted into carbonate of soda and sulphate of lime by means of heating with chalk and coal, and lastly by lixiviation, the soluble

Le Blanc Process.

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ALKALIS. **Alkalis, Alkaline Earths, Alkaline Ashes, etc.**

CARBONATE OF SODA.

Ammonia Soda process.

carbonate is separated in the form now known as soda-ash. The only other process that need be mentioned here is that known as the "Ammonia soda." This depends upon the fact that when carbonic acid is passed through a solution of common salt and ammonia, bicarbonate of soda and chloride of ammonia are formed. This process has been recently carried to a high state of perfection as may be seen from the following facts:—The German production of ammonia soda was 56,500 tons in 1884 and 210,000 tons in 1894.

Soda-ash.

Qualities.

Soda-ash.—By far the greater portion of the carbonate of soda used at the present day may be said to be now obtained by either of the processes indicated. In the production of carbonate of soda by the Le Blanc process much depends on the kind of common salt used and the quality of the chalk or limestone and coal employed. The salt generally preferred is the Cheshire or Worcestershire brine, because of its cheapness, purity, and uniformity of crystals. The soda-ash obtained after lixiviation in the Le Blanc process is now preferred by the soap, glass and paper trades to refined carbonate of soda or even the much purer bicarbonate of the ammonia-soda process. The waste materials left in the lixiviating tanks are utilized in the manufacture of hyposulphite of soda. But the greatest economy in the carbonate of soda industry was effected by the manufacture of sulphuric acid from pyrites in place of the expensive Sicilian sulphur, and it might be said by the recovery of the sulphur in the Le Blanc process or the ammonia in the other process from the waste materials of the lixiviating tanks. In fact in the chemical industries of the present day there can hardly be said to be any "waste materials."

Hyposulphite of Soda.

Sulphuric Acid.

Sulphur.

India's Future Chemical Works.

The extensive deposits of copper pyrites that exist in India if utilized in the combined production of copper and sulphuric acid and the still further manufacture of the phosphatic deposits of India and adjacent countries into superphosphates should open a highly lucrative field of enterprise for India. As an exemplification of such results it may be added that the production of sulphuric acid from iron pyrites was in Germany 358,149 tons in 1882 and 754,151 tons in 1898 and of that large quantity only 25,000 tons were exported, the balance being used up in the exceedingly important German chemical industries which within the past three quarters of a century have expanded from being nominal to a valuation of £50,000,000.

Refined Soda.

Further Stages.—The quality of soda-ash is estimated by the percentage of sodium it possesses. But for the finer sorts of glass and for many other minor purposes a REFINED CARBONATE is required. This is obtained by re-dissolving the ash in hot water, settling, boiling down and re-furnacing—the result being a purer quality of carbonate.

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CARBONATE OF SODA.

Soda Crystals. Domestic Uses.

SODA CRYSTALS may be said to be a well known special preparation that contains 10 parts of water in combination with the carbonate. For household purposes of cleaning, bleaching, etc., soda crystals are still sold. The other substances obtained from sodium carbonate that may be here mentioned are the bicarbonate of soda and caustic soda. Before proceeding to deal with the last mentioned, the Indian manufacture and sources of supply of carbonate of soda may be dealt with very briefly. These have already been incidentally mentioned, namely, *réh* and *barilla*, but to the former must be added, the sources of natural carbonate derived from the waters of certain lakes such as the Lonar in Berár.

Bicarbonate.

Caustic.

Indian Sources.

REH.

(*a*) **Reh or Saji-mati.**—(*Dict. of Econ. Prod., Vol. VI., Part I., 400—27.*)

Composition.

Composition of Reh.—As already explained this is an efflorescence that occurs on the surface of the ground, in most provinces of India. It may be said to be a mixture of the following salts:—sodium carbonate (*sají*), sodium sulphate (*khárí*) and sodium chloride (common salt or *namak*). In most localities the carbonate predominates but in others the sulphate; and in the latter case it is very often associated with potassium nitrate or even with calcium nitrate. Soils badly impregnated with soluble alkali salts are variously designated as *úsar*, *bhádi*, *réhál*, *réhár* and *kalar* (*kalr*), etc., though also employed, denotes as a rule the presence of common salt just as *khárí* usually indicates a soil containing the sulphate. In passing, it may be here remarked that the earlier investigators of these lands speak of the sulphate as being the most abundant. Yule-Burnell's *Glossary of Anglo-Indian Words* defines *réh* as an efflorescent sulphate of soda mixed with chloride and occasionally carbonate. Voelcker (*Report, Improvement of Indian Agriculture, page 37*) says of *réh*. "The salts are principally impure carbonate of soda, but sulphate of soda also occurs largely and with them are found common salt and salts of lime and magnesia."

Variation.

Amount of Salts.

Réh often occurs in such abundance as to give origin to large tracts of desert—and constantly increasing tracts—the surface being literally encrusted with a white snow-like deposit (hence the name *réh* or *réj*=shining)—or the salt may be invisible and only present to an extent sufficient to greatly lower fertility or while still hardly visible, may yet render the soil more or less sterile for at least half the year.

FORMATION. Varying Opinions.

Formation of Usar.—It would be beyond the scope of this review to deal fully with all the opinions that have been advanced regarding the source and formation of these alkali deposits. These opinions vary in degree and detail rather than in fact and mainly in

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consequence of what might be called professional bias. Medlicott (at one time Director General of the Geological Survey) began the study of this subject early in the sixties, and as a member of the Réh Committee of 1877, he wrote a masterly report which may be said to contain all that we know, or are likely to know, regarding the formation and movement of the soluble alkali salts within the soil. These, he tells us, are formed from normal soil materials by the disintegration caused through the growth of plants and tillage. The silicates are broken up by the action of heat, air, water and carbonic acid, etc., with the manifestation of the various alkalis that are formed and re-formed during the several changes that ensue. During the production and maintenance of fertile soils carbonate of soda, for example, is, as a rule, a transitional compound and is destroyed with the elaboration of other and more essential constituents, especially in the presence of lime. In most fertile soils the percentage of that carbonate is accordingly remarkably low. In fact the total of soluble soda salts in good soils rarely exceed 0·1 of which ordinarily one-half may be the carbonate. Crops, more especially cereals, may, however, be grown on soils that contain 0·1 per cent. of carbonate of soda but 0·2 per cent. is sufficient to cause serious injury if it be not found fatal, except perhaps to the so-called saltworts or saltbush—plants that are actually found to luxuriate on briny soils or littoral swamps. At times, however, as already observed, the surface soil may become encrusted with soluble salts, as much as 2 to 6 per cent. or much more being often present. Normally these soluble alkalis are carried by the rain water to the sub-soil and a certain percentage are there absorbed or detained mechanically, in order to meet plant necessities. The soil might in fact be described as a vital filter which, when in a healthy and vigorous condition, retains what is necessary for the support of plant life and rejects what is unnecessary or injurious. A soil is vigorous when it is completely and freely permeated by the water that is carrying its supplies of soluble salts and other chemical re-agents and of heat, air, etc., to every depth and particle. Drainage is in fact to the soil what circulation of blood is to the animal. The soil is abnormal and diseased when, from whatever cause, free permeation is interrupted. The evil consequences of even a temporary cessation of soil permeation may be exaggerated under certain conditions such as (I) recurring periods of hot parching winds, (II) absence of soil covering (*i.e.*, wild herbage or crops and trees) and (III) defective tillage (*i.e.*, superficial ploughing or puddling during flood). These are the very conditions that produce *réh* efflorescence, aided by (*a*) the chemical nature of the original soil materials; (*b*) the physical attributes (or texture,

Percentage Present.

Sterile Soils.

Saltworts.

Vigorous oils.

Drainage.

Soil permeation.

Conditions of Efflorescence.

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as it has been called) of the soil (*i.e.*, abundance of clay and the condition of the clay; abundance of sand or of lime, etc.); and (*c*) the accidental or irregular distribution of (*a*) and (*b*) brought about through countless ages of water action both during the formation of the alluvial plains and subsequently. For particulars regarding the association of concretionary lime (*kankar*) with *réh* the reader is referred to page 140.

Sub-soil Drainage.

Towards the close of his report, Medlicott emphasises the necessity for sub-soil drainage in the following words:—"The one measure that is of obvious necessity under any aspect of the case, and that may be at once put in hand, is deep main drainage. It would certainly alleviate the evil in what are at present the most threatening cases, and it would also be a necessary feature of any general scheme of improvement."

Capillary Action.

Capillary Attraction.—Mention has been made of the salts being carried to the surface by capillary attraction. Dr. Center (then Chemical Examiner to the Panjáb Government) wrote in 1880 a most valuable "*Note on Reh or Alkali Soils and Saline Well Waters,*" in which he dealt in great detail with the movement of these salts within the soil and their temporary accumulation on the surface. Hilgard and Loughridge, in connection with the Californian Experimental Station of Tulare, have carried these investigations to their final issue by tracing, in every detail, the actual movement of the salts in sterile soils, before and after irrigation, and have exhibited their results graphically, in direct correspondence with a most critical analysis of practically every inch of soil to a depth of four feet. They have also demonstrated beyond all dispute that this movement to and from the surface is directly a result of imperfect drainage in conjunction with severe surface evaporation.

Movement of the Salts.

Causes.

TREATMENT.

Manuring and Tillage.—Mr. Baden Powell (*Punjab Products, published 1868*) wrote "With regard to the actual practice of the agriculturist in dealing with *Réh* land it may be observed, that in many places drainage has been turned into good effect. If the *Réh* land is not very heavily impregnated, the natives give it constant ploughing, free watering and manure, and this generally renders the land productive, at least for second-rate crops." Some time previously Dr. Brown (then Chemical Examiner to the Panjáb) had investigated the use of lime salts as a manure to be employed in the treatment of *réh* soils and his views were published by Mr. Baden Powell as follows:—"When the deleterious sulphates and carbonates are mixed with *any soluble salt of lime*, such as the nitrate of lime, decomposition occurs and nitrate of soda is formed while carbonate and sulphate of lime are produced. Carbonate of lime is insoluble

Drainage.

Manures.

Use of Lime Salts.

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Nitrates.

Formation of a Nitrate Manure.

in pure water and has no power of injuring plants while nitrate of soda and sulphate of lime are beneficial in supplying them with nitrogen, the former by direct decomposition of its acid and the latter by absorbing ammonia from the air. Nitrate of lime is formed whenever organic matter decomposes in contact with carbonate of lime. Nitrate of lime might be made by treating a mixture of *kankar* and water, with impure but cheap nitric acid made by distilling nitre and *kahi* (sulphate of iron earth) together. The nitrate can also be obtained by mixing animal manure with chalk or lime, in large heaps exposed to air but sheltered from rain." Some years later Dr. Brown addressed a letter on this selfsame subject to the Financial Commissioner to the Panjáb, in which he advocated the use of farm-yard manure and green manure, with such plants as *Calotropis gigantea,* on the ground of their supplying the nitrogen which, in combination with the lime (naturally present in all *kalr* soils), would tend to reduce the carbonate of soda to a harmless condition. Dr. Center (who succeeded Dr. Brown) wrote a long and most instructive report on the chemistry of the *úsar* soils and confirmed in the most striking way Dr. Brown's recommendations for lime nitrate. He also gave an account of the operations in the Utah Basin and other parts of America where heavy nitrating manures were employed as a remedial measure for alkali soils.

Farm-yard Manure.

Green Manure.

American Reclamation Methods.

Gypsum. (*Conf. with Gypsum, page 145.*)

Use of Gypsum.—Later on the sulphate of lime (gypsum) gained a well-deserved reputation as a chemical substance that might be employed with great advantage in the neutralisation of the sodium carbonate in *úsar* soils. On this subject, for example, Dr. Romanis (Chemical Examiner to the Government of Burma) in 1884, reported on the soil of Bulandshahr District in the United Provinces. He was of opinion that the fault lay more in the mechanical texture than in the chemical nature of the soil.

Mechanical Texture.

A Corrosive Salt.

"It is well known," wrote Dr. Romanis, "that an alkaline substance like sodium carbonate is far more injurious to plants than neutral salts like the sulphate and chloride. That alkali can be neutralised by sulphate of lime (gypsum) which produces carbonate of lime and sulphate of sodium." Professor R. Wallace has repeatedly urged the importance of gypsum "as an antidote to alkali soils." In his *Rural Economy and Agriculture of Australia and New Zealand* (*page 183*) he says: "The carbonate of soda is by far the most injurious of all the alkali salts enumerated under the three headings. This arises not only from its corrosive power, but is also due to the peculiar action (shared with the carbonate of potash) which makes it almost impossible to produce a tilthy condition in

Antidote to Alkali.

Tilthy Condition Impossible.

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true clays. They are maintained in the most impalpably divided condition—that of well-worked pottery clay, "in place of the flocculent though tilthy state it assumes in a cultivated soil." So far as I can discover Dr. Voelcker (*Report, Improvement of Indian Agriculture*), makes no mention of the use of gypsum or any other lime salt in the reclamation of *úsar* lands.

Recent Investigations.

The next most important step, in the study of the chemical treatment of *úsar* soils, may be said to be Dr. Leather's various papers that have appeared in *The Agricultural Ledger* (*Nos. 12 and 13 of 1893 and Nos. 5, 7 and 13 of 1897*). These give extensive analyses of soils, waters, etc., from the entire alkali area of India. They contain the results of practical experiments to test the amount of soluble alkali salts that may exist in soils before these become poisonous to vegetation. They indicate the plants that first show signs of succumbing to the influence of these salts and the amount of each salt that proves fatal. By special pot cultures of various plants Dr. Leather proved that sodium carbonate is (as has always been upheld) infinitely more injurious to plant life than are any of the other soda salts. But perhaps the most instructive part of Dr. Leather's researches was the demonstration of the physical property (alluded to above by Romanis, Wallace and others) possessed by carbonate of soda which greatly augments its injurious chemical influence on plants. While filtering the soil in order to obtain their soluble salts, Dr. Leather observed that certain soils could practically not be filtered. A little muddy water percolated through at first but very soon the surface of the filter cloth became coated with a perfectly impenetrable layer that was quite impervious and further filtration practically ceased. The soils that manifested this peculiarity were those most highly charged with carbonate of soda. To remedy this defect Dr. Leather experimented with gypsum and soon ascertained that its well-known merit as a chemical manure, in the reclamation of *úsar* soils, rested as much on the destruction of their power to form an impervious deposit as in the reduction of the "white" to the "black alkali." It would thus appear that should climatic and soil conditions exist, sufficient to give origin to a *réh* efflorescence containing carbonate of soda, there must sooner or later be produced (at a certain position or depth) an impenetrable layer through which surface percolation of water would be impossible. This water-proof layer may not be sufficiently developed to be visible to the naked eye as a "hard pan," but if carried near to the surface it will give origin to a crust of salt. It may thus be inferred that sub-soil drainage, below an impervious layer would be next to useless, unless the soil be chemically

Percentage of Alkalis.

Action of Sodium Carbonate Demonstrated.

Physical Property of Soil also Demonstrated.

Principles Involved.

Hard Pan.

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Tree Cultivation.

treated with some of the soluble lime salts or be penetrated by deep pits filled in with fresh soil for tree cultivation. It would indeed seem probable that the surface vegetation that has been reported as accompanying successful tree cultivation may be due very largely to the pits dug for trees having acted as openings through the impenetrable layer by which the soluble salts of the surface have been washed into the natural drainage.

Is complete Neutralisation Essential?

By way of concluding these observations regarding gypsum, it may be suggested that it does not seem necessary to assume that the exact amount of that salt which would be required chemically to neutralise the ascertained weight of carbonate present, need be given as a manure, before beneficial results may be looked for. Gypsum is useless without water and unnecessary where the carbonate is absent. Water must be carried right into the soil and through it to the sub-soil. Unless, therefore, a free sub-soil natural drainage exists it must be provided before any heavy expenditure be incurred for gypsum as a manure. At the same time land treated with gypsum should be planted with saltworts or other plants that have been found possible of cultivation. If these can be raised on the soil it seems highly probable, provision may have been thereby made for the injurious salts being washed out of the soil, long before it has been necessary to add, from a financial point of view, a prohibitive amount of gypsum.

Important Factors.

Saltworts. Soil washing.

Results.

American Results.—This leads, therefore, very naturally to a brief reference to the admirable investigations and practical results that have been attained by Hilgard and Loughridge in the reclamation of alkali wastes in California. These officers performed a most extensive series of experiments and analyses with the result that they arrived emphatically at the same conclusions as our Indian experts, namely, regarding the formation of these salts, their movements in the soil and lastly their treatment with drainage, chemical manures, and selection of crops. The difference between America and India in this matter may be said to be that in the former country the scientific experts were at the same time the administrative staff that had to deal with the alkali wastes. Their observations were not treated as scientific theories but were at once put to practical test, with this result that alkali wastes are in that country not only regarded as comparatively easy of reclamation but have actually been largely turned into some of the most profitable of lands.

Direct Accord with Indian experts.

Reclamation easy.

Soil protection.

Helpful Vegetation.—Medlicott urged that to protect the soil from the excessive heat of the summer months and consequent injurious capillary efflorescence, it was most important to alleviate the serious Indian defect, *viz.*, the almost total absence of arborescent

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vegetation from the agricultural tracts of the country. But there is an aspect of vegetation that seems to have entirely escaped Mr. Medlicott's observation, namely the employment of certain plants as direct agents in reclamation. It is well known that many plants not only can survive on soils that contain a proportion of alkali that would be fatal to others, but that they actually luxuriate under such soil conditions. Of this nature may be mentioned the saltworts. Long, therefore, before reclamation could be carried to the extent of admitting of ordinary crops or even of arborescent cultivation, the soil might be protected from the sun by saltworts and have at the same time large amounts of its poisonous salts removed by the temporary cultivation of such plants. **Direct agents to reclamation.** **Saltworts.**

This subject has not, however, been entirely neglected in India. It was believed that were alkali lands protected from cattle for a number of years or even annually from the close of the rains through the hot months, the plants produced during the rains might be encouraged to survive and even others, including trees, to gradually invade such protected localities, until, in a few years' time, the growth of a soil garment might ultimately prevent efflorescence. Such experiments have actually been conducted and with considerable success. The plant found to first invade the protected barren lands was the grass known as *khár úsara* (*Sporobolus arabicus*) which from its vernacular name may be inferred to be a salt loving species. *Sporobolus coromandelianus* (*the bhurburoi*) also springs up readily enough but only during the rains. It, however, affords useful fodder, although it does not protect the land from the summer's heat. After partial reclamation the *dáb* (*Eragrostis cynosuroides*), the *dúb* (*Cynodon dactylon*), the *batt* (*Dyplachne fusca*), the *janewa* (*Andropogon annulatus*) and several other species readily enough appear. Since fodder is of necessity a pressing need in all parched lands, it is valuable to know the Indian grasses that should be first resorted to in reclamation operations, but it is unfortunate that the true saltworts have not hitherto been seriously investigated in India as desirable preparatory vegetation to any of the grasses named. We read of a few desultory experiments having been put forth to acclimatise the Australian salt-bush, but it does not seem to have occurred to any of our Indian experts that this country possessed perhaps a richer and more varied assortment of indigenous saltworts than is to be found in any other country. In the Panjáb and elsewhere a few of these have been (one might almost say) systematically cultivated for the production of barilla, but not one of them, so far as I can discover, has been seriously investigated as a preparatory crop in *úsar* reclamation. **Protection from cattle.** **Soil garment.** **Invading grasses.** **Fodder a necessity.** **Acclimatisation of Saltworts.** **Barilla-Yielding species.**

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Study of crops necessary.

It is interesting in this connection to record that halophytic plants when removed from their wild conditions and cultivated as regular crops may be made to live on soils that contain practically no alkali and yet when employed in alkali reclamation they at once take kindly to soils highly charged with these salts. Of this nature may be mentioned all the forms of cabbage, cauliflower, beet, asparagus, etc. These and such like vegetables may be grown luxuriantly on reclaimed salt marshes and alkali impregnated soils, when, for example, most forms of the pea family would readily succumb. Then, again, it has been found that even of the grasses and cereals some species, such as the maize, can stand a quantity of alkali that would be fatal to wheat. These and the like considerations point conclusively to the necessity for a systematic study of the Indian wild vegetation, saltworts, regular crops, fodder plants and trees, with a view to lists of plants being framed in relation to sodium carbonate, sodium sulphate, sodium chloride and perhaps to the total mixed sodium salts. These might start with the amount of each salt present in a soil that would prove fatal to all vegetation, then give the plant found to survive in the highest amount and pass on to exhibit progressively all the others. Such lists, if they dealt with a fairly extensive series of plants, would furnish the urgently needed means of a selection, suited to each province, for cultivation during reclamation operations. In the attempts hitherto made to organise plantations of trees, experiment has in this country, for the most part, been pursued in the least satisfactory manner possible, *viz.*, by laying out large plots of land under trees regarding which very little if anything for certain was known as to their suitability or not to the purpose desired. The trees chiefly experimented with and those most highly commended by Dr. Voelcker and others) have been *Acacia arabica, Butea frondosa* and *Dalbengia Sissoo*—all three members of the pea family. Although a certain success has been spoken of as attained, one still feels disposed to suggest that a better selection might be possible. The greatest fault, however, with all the Indian endeavours at reforestation, as with the efforts to produce fodder by enclosing and protecting selected experimental plots, has been the impecunious craving and shortsighted policy of desiring immediate returns from reclamation operations of barren lands.

Pea Family Plants.

List of Plants in Relation to Alkali Soils.

Tree Cultivation.

Results.

Shortsighted Policy.

Industrial Uses.

Preparation from the Soil.

Industrial Uses of Soda.—Incidentally this subject has been already dealt with. Throughout India soda soils are washed and more or less pure carbonate obtained. At one time a fairly large trade was done in this way in South India (Salem, Mysore) and expectations of a considerable development entertained. Licenses are granted in Behár, the United Provinces and elsewhere

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for the manufacture of *saji* and *rasi* (two qualities of carbonate of soda) from saline earths. The object in licensing the industry is to protect the revenue, since from the factories concerned fairly large quantities of common salt are educed, especially at the factories and refineries for the production of saltpetre. (For method of manufacture see **Glauber's salt**, page 135.)

CARBONATE OF SODA.

Common Salt Educed.

Lake Supplies.

Carbonate of Soda of a very pure kind is regularly prepared at the Lonar lake of Berár. Ball says (*Econ. Geology, page 494*), "Blocks of mixed salt are obtained by divers in certain parts of the lake, and the waters of the lake, on evaporation, deposit salts among which the principal is the carbonate of soda. The local names for these products are *dalla*, which consists of a close collection of acicular crystals, between two compact surfaces; *kuppal*, a thin kind of *dalla*, principally of red colour; *papadi* or *papri*, a white saline froth."

Different Qualities.

Preparation from Reh.

Whether obtained from soil efflorescence or from salt lakes by treatment with sulphuric acid, the mixed salts (especially where the greater proportion is already the sulphate), may be reduced to a salt-cake, (similar to that obtained at the first stage in the Le Blanc process of manufacture), and by calcining with lime and coal that may be converted into soda-ash. At Awah, in the United Provinces, an attempt was made, in 1880, to utilize the *réh* efflorescence in the manufacture of glass and glass-beads. A complete set of tools was imported from Venice, but the following among other conclusions appear to have been arrived at, regarding these and all other experiments at utilizing the alkali deposits in glass-making:—

Glass-making.

Conclusion.

(*a*) The impurity of the alkali prevents the formation of good quality of colourless glass.

(*b*) It is, therefore, necessary to organise chemical works to produce pure alkali.

(*c*) Good beads could be made but doubtfully at a lower price than they can be imported.

(*d*) Improvement of glass manufacture in India would depend on the work being done on a large scale with skilled supervision.

Native Industries.

Wherever soda efflorescence is at all abundant, the Native industry of glass-making (such as it is) is more or less prevalent, especially that of glass bangles. But *réh* and *sají* are put to an infinite variety of other uses by the Natives. They are employed for dissolving crude lac and *kamela*, preparatory to dyeing silk, also for extracting the crimson dye from safflower in cotton dyeing. They are used for bleaching silk, cotton and wool. *Sají* is employed in making

Dyeing.

Bleaching.

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CARBONATE OF SODA.

Paper-making. Sugar-manufacture. Tobacco Adulteration. Medicine.

country paper from hemp in Farukhábád. Both salts, in conjunction with shell-lime, enter into the composition of country soap. White *réh* sprinkled into boiling cane juice is utilized to neutralize the organic acids in the manufacture of sugar very similar to the use of lime (page 142), barium carbonate (page 136) or strontium carbonate (page 148) in Europe. *Réh* is an adulterant of tobacco and is added to increase the weight. In Native medicine these salts are supposed to be digestive and hepatic.

Ceramic Art. Early Bengal. Experiments

The effort to utilize the peculiar clays that are in association with carbonate of soda, in the potter's art, has not as yet received the consideration that it deserves, although the ceramic art of India has been the subject recently of special study. As a historic fact, that has escaped the attention of most writers on this subject, it may be said that some 60 years ago, Sir William O'Shaughnessy submitted to the Government of India the results of an enquiry which included extensive trials of Bengal clays, such as Kolgong *khári*, *Saban miti*, Rotas clays, Moulmein clays, Singapore clays, etc., as also numerous experiments in glazing the pottery turned out. (See *Appendix to Bengal Dispensatory, pages 700—17.*)

Black Salt. Medicine.

Black Salt. (*Kála-nun*)—Is an article of some importance in the local markets of India. It is prepared in Upper India, chiefly at Bhiwání in Hissár. Common salt is heated with the chebulic and emblic myrobalans together with *sají*, until a sort of fusion takes place. The article so manufactured is used as a medicine.

Phuli. Flavouring for Tea.

Phuli.—This is believed to be a form of carbonate of soda. It is imported into Leh from Changthan, Rupshu and Nubra in Ladákh. It is said to be extensively used for mixing with tea to bring out its strength. It is exported to Kashmir and Kúlu and into Lower India. The Bhotyas are said to use it for washing clothes and for dyeing wool. The average imports appear to be from 50 to 120 tons and the average cost about Rs. 6-4-0 per maund.

BARILLA.

(*b*) **Barilla or Sají-khár.**—(*Dict. Econ. Prod., Vol. I., 394—9*).—A century ago the manufacture of carbonate of soda from the ashes of certain saltworts was an important industry. Attention was accordingly early directed to India as a source of supply for Great Britain to supplement that obtained from Spain. Roxburgh, Royle, Baden Powell and many other writers in succession, described the existing trade and discussed its possible developments. Roxburgh (*Flora Indica, Vol. II., page 61*), practically speaks of the future of the Indian barilla trade as being of national importance. He explains that one species of *Salicornia*, one of *Arthrocnemum* and one of *Salsola*, which are extremely abundant plants on the Coromandel Coast, might be made to yield barilla sufficient to make soap

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The World's Supply.

and **glass** for the whole world, since labour is cheap and population abundant. That opinion was written before the date (1791—93) of the famine that removed fully half the labouring classes of Coromandel. It need hardly be said, however, that the discovery of **Le Blanc's** method of preparing sodium carbonate chemically from common salt, not only destroyed these and all other similar expectations of a remunerative trade in barilla, but revolutionized the world's necessities and demands for the salt. At the present moment, were not only the available lands of Coromandel but of all similar suitable tracts in India, to be devoted to the production of barilla, they very possibly could not supply a tithe of the world's present requirements for carbonate of soda.

Expectations. Falsified.

Pearl-ashes.

But **Roxburgh's** further statements regarding the kindred subject, namely, the production of pearl-ash, are even more amusing and interesting. I shall quote his own words. "Our extensive, and I may also say impenetrable forests, which cover such large tracts of the best lands in India, might by degrees be cleared, and turned to potash, for the same reasons, and by the same means" as the saltworts of the coast might yield barilla. "Certainly, labour is as cheap here as in Russia." "In this hot climate we have many advantages, *viz.*, immense tracts of wood of the most solid texture which requires little labour to prepare it for the fire, on account of the great drought and heat which prevail at the season this manufacture could be best carried on. The same heat and drought is fully sufficient to evaporate the ley without the least assistance of fire." "Our extensive and impenetrable forests" sounds remarkable when it is borne in mind that one of the reasons assigned at the present day for the recent expansion of the area of carbonate of soda impregnated sterile soils, is the absence of forest. We know as a matter of trade history that India never actually burned her forests in the production of pearl-ash. Moreover **Roxburgh's** "impenetrable forests" had very possibly no reference to Northern India. Still his remarks are significant since he was one of the best informed and most careful observers and at the same time most accurate writers who ever lived in India. His words cannot, therefore, be placed on one side as unworthy of consideration. They doubtless denote that 100 years ago forest was very much more plentiful than at the present day and was possibly ruthlessly destroyed to make room for temporary cultivation.

Impenetrable Forests.

Destruction of Forests.

Royle (*Productive Resources of India, published 1840*) concludes his account of barilla with the statement that **Dr. Helenus Scott** had obtained the gold medal of the Society of Arts for sending from Bombay a substitute for barilla, *viz.*, "a considerable quantity of mineral alkali, which he describes as being dug out of the ground." Now one would have expected, in a work devoted to the Productive

Early Mention of Mineral Alkali.

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Resources of India, that the existence of *úsar* tracts, highly charged with carbonate of soda (had they existed to the same extent as they do at the present day) would have engaged Royle's attention and been the theme of a special chapter—the more so since he was for some time resident in Sahāranpur. But Royle neither alludes to the destruction of agricultural lands, effected by *reh* efflorescence, nor suggests the possibility of the accumulation of salts on the surface of the ground being utilized as a source of alkali for the industries of the country. In fact he only incidentally (and as if a great curiosity) refers to Dr. Scott's discovery of *"Mineral Alkali."*

Was Reh a Serious Question in 1840?

Punjab Barilla.

Baden Powell (*Panjáb Products, Vol. I., 86, published 1868*) gives a more instructive account of the barilla industry of that province. Very little of importance has been since written on this subject and the following abstract may, therefore, be given from that work:—The process by which this substance is prepared is carried on during the month of October and three following months. The plant after being cut down is allowed to dry. The next step is to dig a pit of a hemispherical shape, about 6 feet in circumference and 3 feet deep. One or more vessels with holes perforated are inverted and placed in the bottom of the pit, the holes being kept closed until the alkali begins to flow when they are opened by a stick previously arranged for that purpose. The dry plants are gradually burnt, and during the process a liquid substance is found to run down into the inverted vessels. After this has taken place, the residue is stirred up by means of a flat piece of wood and kept covered over for three or four days till it cools. Care must be taken not to allow water to get to the molten liquid, otherwise the whole mass would blow up. In the inverted vessels will be found a pure form of *khar saji* (sometimes called *lota* (pot) *saji*) and in the bottom of the pit an impure form containing a mixture of ashes.

Season of Cutting.

Description of process.

Khar Saji and lota Saji.

In the *Dictionary of Economic Products* more recent papers are reviewed. The Deputy Commissioner of Multán says that in that district the plants are collected in January and February. He then observes that the land on which barilla-yielding plants grow was in 1883-1884 leased for Rs 7,907. The Settlement Report of Shahpur District contains an interesting account of the barilla industry in which it is stated that the farming of the monopoly fetches upwards of Rs 8,000 a year. The quantity of *saji* manufactured is said to be about 10,000 maunds. In Montgomery and Jhang the *khár (or khangan khár*) plant is *Haloxylon recurvum* and this is supposed to yield the finest quality of *saji* the inferior qualities are said to be made from the various species of *laná* of which the *gorá laná* is the best *(Salsola fœtida).*

Season of Collection.

Revenue.

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BARILLA.

Sind Barilla.

In Sind the plant that yields the best *saji* is said to be known as *laní*. This grows wild all over the province and springs up spontaneously after a copious fall of rain. The process of manufacture pursued in Sind differs from that described in connection with the Panjáb in the circumstance that earthen pots (*lota*) are not employed. A piece of ground is flattened and a pit dug of a size proportioned to the extent of the contemplated manufacture—perhaps from 1½ to 3 feet in diameter and a foot in depth. On the margin of this pit or all round about it, a fire is kindled and on this the dried *laní* plant is thrown continuously. The alkali flows into the pit and when the burning has been completed, the alkali is stirred with a stick for some hours, then left to cool and dry when it is ready for use. This industry flourishes most at Kutchí in Khelát where over 5,000 maunds are annually prepared. In Shikárpur a like quantity is made and in Thar and Párkar about 3,000 maunds are annually turned out.

Description of process.

Extent of Trade.

Aden Barilla.

There seems also to exist a fairly extensive manufacture of carbonate of soda at Aden from the so-called *ADEN BALSAM (? Suæda nudiflora)*.

Madras Trade.

The publication of the article barilla (in the first volume of the *Dictionary of Economic Products*) led to a fairly extensive correspondence on the subject of a possible extension of the industry. In 1888 the Madras Government asked the assistance of the Director of Agriculture in the Punjab. The result was that Mr. J. R. Drummond, then Deputy Commissioner of Karnái, was invited to draw up a report on the Panjáb saltworts actually in use in the manufacture of barilla, and this was furnished to the Madras Government. After considering the information procured from various sources, the conclusions arrived at by that Government may be put thus:—

Madras Opinion.

(1) It was cheaper and more convenient to obtain sodium carbonate from alkali deposits in the soil (such as the well-known *dhobis'* earths of various parts of the Presidency) than to burn saltworts and manufacture barilla;

(2) the imported pure salt could be had at such a low price that it was doubtful whether either methods were likely in the future to compete successfully.

Saltworts.

List of Chief Plants.

(*c*) **Indian Saltworts.**—The following may be given (in continuation of pages 123, 124) as an alphabetical enumeration of the better known saltworts of India, in which all those that might be successfully tried in reclamation of *réh* efflorescence have been shown as well as those actually employed in the manufacture of barilla.

ALKALIS.

Alkalis, Alkaline Earths, Alkaline Ashes, etc.

INDIAN SALT-WORTS.

Arthrocnemum indicum, *Moq.* (*Dict. Econ. Prod., Vol. I., page 328*).

Coromandel. Plants.

(Syn. Salicornia indica, *Willd.*, as in Roxburgh's *Flora Indica, Vol. I., page 85;* the *Jadu palang* of Bengali; *Machola, machur, ghuri, chil,* of Western India; the *Umari* of Tamil; and *Koia-pipali* or *koya-pipili* of Telegu.) This is one of the four plants of the Coromandel coast recommended by Roxburgh, in the passage quoted above for the production of barilla. It is a native of the salt marshes of Bengal, Madras, and Bombay.

Atriplex repens, *Roth,* (*Dict. Econ. Prod., Vol. I., pages 349-51*).

Deccan Plant

(Syn. Obione Kœnigii, *Moq. Wight Ic. t. 1790.*)
A shrubby plant found on the coast of South India (Tuticorin) and of the Deccan Peninsula. Referred to in official correspondence as having been experimented with unsuccessfully in Madras as a source of barilla.

Atriplex Stocksii, *Boiss.*

(Syn. A. Griffithii, *var.* Stocksii, *Boiss.*. A. repens, *Aitchison, Cat. Pl. Pb.*) A shrubby species common in the salt marshes at Karachi, and fairly frequent in Guzerat where it is known as *Juri.*

Halocharis violacea, *Bunge.*
A small diffuse prostrate annual common in the Peshawar valley, the Western Punjab, the Salt Range and Baluchistan. Might be useful on alkali soils.

Haloxylon recurvum, *Bunge,* (*Dict. Econ. Prod., Vol. IV., page 199*).

True Barilla, Plant.

(Syn. Salsola lana, *Stocks,* and Caroxylon Griffithii of *Dict. Econ. Prod., Vol. I., page 399;* it is *khár* or *laghme* of the Punjab and *khári-laní* of Sind.) A straggling bush met with plentifully in the Central and Western Punjab plains and Salt Range but occurs also in Sind, the Deccan Peninsula (Coimbatore) and in Burma. It is the most important barilla yielding species and according to Drummond is most abundant in Jhang and in the "Bar" tract generally.

Haloxylon multiflorum, *Bunge.*

H. salicornicum, *Bunge.*

Barilla Substitutes.

These two shrubs appear sometimes to be used in place of or as an adulterant for No. 5 above. The former occurs in the Punjab and the latter in Sind.

Kochia indica, *Wight,* (*Dict. Econ. Prod., Vol. IV., page 567*).
The herbaceous plant occurs from Delhi to the Indus also in the Deccan Peninsula on salt soils (Coimbatore). It is in the Punjab known as *Bui* or *kauro ro.*

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INDIAN SALT-WORTS.

Salicornia brachiata, *Roxb.*; (*Dict. Econ. Prod., Vol. I., page 387*).

This small shrub is found on most salt marshes (in Bengal, South India (Tanjore), &c.). It is one of the plants specially recommended for experiment by Roxburgh. He says that it is found plentiful on low wet ground overflowed by the spring tides. He gives it the Telegu name of *Quoilu* or *koyalu* and in Tamil *Umarí-kírai*. Recommended for Trial.

Salsola fœtida, *Del.*; (*Dict. Econ. Prod., Vol. VI., Pt. II., page 392*).

A large shrub plentiful in the Central and Southern Punjab or from Delhi westward to Sind and Baluchistan. It is the *Laná, mótí láne, gorá lána,* or *laná góra* of the Punjab; *Shora* or *shorga* of Pushtu; *Lanan* of Sind and *Ella-kura* of Telugu. It is a saltwort much valued as a fodder for camels and sometimes employed in the manufacture of barilla, especially in the Hari-rud, where it is used in the preparation of *khár* or *ishkhár*, as it is there called. Chief Substitute for the Khar Plant.

Salsola verrucosa, *M. Bieb.*

A stout hoary shrub or tree met with in the Punjab from the Peshawar valley South-Westwards.

Suæda fruticosa, *Forsk.,* (*Dict. Econ. Prod., Vol. VI., Pt. III., page 386*).

(Syn. **Salsola indica,** *Wall.,* **S. lana,** *Edgew.*) This is the *Lunak, choti-laní, usák laní, khár-khusa, baggí-lana* or *dana* of the Punjab. It is also the *Limch* of Pushtu; and *Ushak laní* of Sind. It is a sub-erect shrub met with in North-Western India from Delhi throughout the Punjab to Sind. This is used mainly as an adulterant in the manufacture of barilla. Adulteration of Barilla.

Suæda monoica, *Forsk.*

A shrubby species met with on the sea coast in the South Deccan (Tuticorin).

Suæda nudiflora *Moq.,* (*Dict. Econ. Prod., Vol. IV., Pt. III., page 386*).

A shrub met with on the coast of Bengal, Bombay and South India. This is *Morasa, moras* of the Mahratta; the *Khári-láni* of Sind; the *Geria* of Orissa; and the *Kiray* of Tamil; and *Rava kada* or *reyi kada* of Telegu.

Suæda maritima, *Dumort.,* **Dict. Econ. Pro.,** *Vol. VI., Pt., III., page 386*).

A herbaceous species occasionally becoming shrubby, met with in the Upper Gangetic Plains from Delhi to the sea coast of Bengal, Bombay and the Deccan, on salt impregnated soils. The leaves are universally eaten, specially during times of famine (Roxburgh). According to Drummond most of the references by authors to **Suæda nudiflora** A Useful Vegetable.

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BORAX.

should in reality be taken to denote this plant. It is the *Laní* of the Punjab ; the *Khári laní* of Sind ; the *Laná* of Mahratta ; the *Yella kiray* of Tamil ; and the *Ila* or *Ella-kura* of Telegu.

Vernacular Names.

(B) **BORAX OR SODIUM BI-BORATE.**—*Dict. of Econ. Prod., Vol. I., pages 504-11.* ; The Mineral Industry, 1900, pp. 57-59. This salt is known in India under an extensive series of vernacular names such as *Sohágá tinkál, kuddia khár, tankankhár, venkaram, velligaram, billigárú, lakhiya, vavut,* etc. It is known in Sanskrit as *Tan-kana* and in Persian as *Tinkar* or *tankar*. In some parts of the Punjab frontier and Tibet it is known as *taslé* or *sal* (*shal*) (one variety being *chú tsalé* or water-borax, the other *tasle mentog* or flower-borax.)

Early Mentions.

History.—This substance was known to the ancient Sanskrit authors and is mentioned by Susruta. From the Sanskrit is derived doubtless its Persian and most of its Indian vernacular names as also its old English synonym *TINCAL*. Perhaps the earliest mention (by a European writer) of this substance, in connection with India, is the reference by Garcia de Orta (in 1563) in which he says it is known to the Guzeratis by its Arabic name of *tincar*. It is mentioned by Abul Fazl in the *Aini-Akbari* (1590) and is called *tangar*. Hove (a Polish savant who visited India in 1787) describes the salt as refined in Káthiáwár. Ainslie (*Materia Indica*, published 1826) gives a good account of it as a drug and says that the process by which *TINCAL* was refined into borax, was kept a secret by the Dutch. Royle (*Productive Resources of India*) gives a brief notice of the substance, but by far the most complete statement hitherto published may be said to be that given by Baden Powell in his *Panjáb Products* (published, 1868). This reviewed the reports of Cunningham, Hay, Edgeworth, Marcadieu and others. Ball's *Economic Geology* brings the Indian literature to the date of 1881 since which time little of importance has been ascertained except that the foreign exports from India have dwindled to insignificance.

Decline of Indian exports.

Sources.

Indian Area.

Sources.—Borax proper is a native borate of sodium found, along with common salt, on the shores of certain lakes in the Panjáb and North-West Tibetan Frontiers and within Tibet itself, and possibly beyond in Persia and China. The Indian area may thus be said to commence in Puga valley of Ladákh and to pass East to the lakes of Rudokh. To the South of Lasha, at the Yamdok-cho, borax is also obtained. Holes are dug in the ground in many parts of the deserts of Tartary and within these tincal is said to collect.

Trade Routes.

The Western supply (*viz.*, from Puga) enters India by Kúlu and is refined at Sultánpur before being consigned, *viá* Mandi and

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BORAX.

Bhaji to Simla or *viâ* Rámpur in Bashahr to Jagádhri and thence to the plains. Smaller quantities from this same source also find their way through Chamba to Núrpur or to Kashmir and Lahore. Tibetan borax enters India across the frontier of the United Provinces. Atkinson furnishes an interesting account of this traffic. The borax he says is collected in June to September and sold at certain markets. It is brought by Bhotiya traders and purchased by the merchants at Rámnagar where it is refined.

Refined Borax.

Economic and Industrial Uses.—Borax is used extensively as a mordant in dyeing and calico-printing. Medicinally it is viewed as a tonic, useful in loss of appetite and painful dyspepsia, and also as an exceedingly valuable detergent in affections of the skin. The antiseptic and disinfecting property of borax, although fully known, might, as it seems, be much more extensively taken advantage of than appears to be the case. For household purposes, its uses are practically limitless. As a substitute for soap and soda crystals, it may be said to clean without destroying colour. As a preservative for meat, it is invaluable and it is probable that as an insecticide (especially in the tea garden) it would be found unrivalled. Its most important use may be said, however, to be for glazing pottery and as a simple and convenient enamel for metallic surfaces, such as the dials of watches and clocks or domestic enamelled metal wares. It acts as a flux in the formation of a glass which has a low melting point and thus affords a material that may be employed even in the ornamentation of the surface of glass or glass vessels, since it can be fused and fixed at a temperature lower than what would re-melt the glass on which it has been painted. But ornamentations produced by borax glass are generally held to be unstable, because of the fact that borax is rendered anhydrous by fusion, but in time gradually absorbs moisture and becomes hydrated and efflorescent, when the glaze made of it splits and crumbles to pieces. Sir William O'Shaughnessy was instructed by the Government of India (in 1839) to investigate the question of the production in India of glazed pottery sufficient for use at Indian hospitals. His report will be found in the appendix to the *Bengal Dispensatory*, and on *pages 710 and 711* he gives a most instructive description of the lime-borate that he employed.

Industrial Uses. Mordant. Medicine.

Antiseptic.

Det ergent.

Insecticide.

Glazing Material.

Glazed Pottery.

Borax may be said to be invaluable in welding and is employed by blacksmiths, brass-founders, and electroplaters. It is largely consumed in the manufacture of glass beads, imitation precious stones, certain qualities of glass and descriptions of cements. It is in fact fairly extensively utilized by the Indian jewellers in the manufacture of artificial gems and with shellac it forms a most

Metal Welding.

Glass Beads.

Precious Stones.

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BORAX. Varnish. Soldering.

valuable varnish. In soldering oxidisable metals its action is to clean the surface by fusing away the oxides into a borax bead. Similarly it is employed by the Indian jewellers to cleanse gold and silver ornaments. Plumbago pots are found to last very much better if after being annealed in the oven they are painted with a solution of borax. Lastly borax is employed as an ingredient in certain toilet soaps and cosmetics and one of its most curious and interesting uses is that of its employment in the production of a self-trimming wick in candles. For this purpose the wick is saturated with borax, then made into a candle. When ignited an incandescent bead is formed that greatly improves the light-giving property of the flame, while at the same time the wick, being weighted by the bead, turns over to one side and thus protudes sideways out of the flame. In that position it is readily oxidised and passes away as carbonic acid—thus dispensing with the necessity of snuffers.

Soap. Cosmatic. Candle Wicks.

TRADE.

Trade.—For some years past the foreign demand for Indian borax has been steadily declining, in consequence of the Italian manufacture from boracic acid and sodium carbonate, as also in consequence of the discovery in California and Nevada of limitless supplies. So recently as 1886-87, the foreign exports of borax were 24,273 cwts., valued at R5,80,637. During the past five years they have shown an average of 4,300 cwts., valued at about R85,000. The internal consumption has not, however, declined materially. In 1897-98, the imports across the land frontier to India were 15,273 cwts.; in 1898-1899, 16,564 cwts.; in 1899-1900, 20,315 cwts.; in 1900-1901, 18,621 cwts., and in 1901-1902 they were 31,085 cwts. valued at R3,61,446. It will thus be seen that borax is an article of considerable importance in the industries of this country and it is satisfactory to know that the local supplies have proved sufficient to check materially imports from Europe orAmerica.

Foreign Exports. Transfrontier Imports.

CAUSTIC.

(C) **Caustic Soda.**—(=*Kshará* in Sanskrit).—So much space having been devoted to carbonate of soda and to Sodium bi-borate, the present salt must be disposed of in the briefest possible manner. At the present day it may be said that India's supply comes entirely from foreign countries. One of the Indian paper-mills is believed, however, to have attempted the preparation of its own supplies from the *réh* salts found in the neighbourhood but it is not known whether its endeavours in that direction were successful.

Paper Mills.

Electric Separation.

The greatest possible interest has been aroused in Europe and America, through the discovery of a method of direct decomposition of common salt into caustic soda and chlorine gas, by means of electricity. With regard to Electro-Chemistry the reader might consult *The Mineral Industry* for 1900, (*New York*), pages 763—772.

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CAUSTIC SODA.

The Indian press have hailed the discovery of the direct decomposition of salt as bringing a cheap supply of alkali to the doors of our Indian soap works, paper-works, etc., owing to India possessing a limitless supply of sodium chloride. The great recommendation to India of this new method lies in the fact that sulphuric acid is not required. Without sulphuric acid Le Blanc's manufacture of soda-ash could not be brought to bear on our supplies of common salt or of *réh* efflorescence—hence in all probability, the backwardness of India in chemical enterprise. But it must not be forgotten that India's total demand for alkalis could not at present support chemical works on a scale of magnitude to admit of their under-selling the chemical works of Europe, even while these are burdened with heavy freight charges and import duties. Alkali Works.

(D) **COMMON SALT or SODIUM CHLORIDE.**—Subject too large to be dealt with here.

(E) **GLAUBER'S SALT or SODIUM SULPHATE.**—This is generally known in India under the name *Khari* or *Kharinun* and as already explained (page 117 *et. seq.*) it is met with as one of the efflorescent salts that constitute *Réh.* It has been shown (page 125) that the chief use of this salt might be regarded as the preparation of carbonate of soda. Its production is, at all events, the first stage in the Le Blanc process of soda manufacture and where met with at all abundantly as a surface efflorescence it might be viewed as first stage of the Le Blanc process accomplished without the expense of sulphuric acid having been incurred.

Preparation. This is in India derived from *réh* efflorescence, either by solar evaporation (*abi*) or by artificial heat (*jaria*) and by a method very similar to that pursued with crude saltpetre. The quality of the earth collected is of course different in each case but the nature of the filters, boilers and pans employed is the same; and for evaporation and condensation of the brine, boilers and *chunam* pans are both used, the former in Behár and the latter in the United Provinces of Agra and Oudh, where prolonged dry hot weather may be more confidently reckoned on than in Behár. *Patna-khari*, as the *khari* produced in Behár is called, is used chiefly for preserving hides, and also as a cathartic for cattle; it sells at from 8 to 12 annas a maund. It contains very little sodic chloride. *Khari* produced up-country by solar evaporation is much used as a cathartic for cattle. It contains a considerable percentage of common salt (20 to 30, and sometimes even more), and realises fm 12 annas to one rupee per maund. Patna-Khari.

Industrial Uses.—The chief economic use of Glauber's salt may be said to be (as already remarked) the curing of hides for Uses.

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GLAUBER'S SALT.

which purpose it is better suited than common salt, owing to the tendency of the latter to absorb water and soften the hides. The *khari* (or *chamra-khari*) of Behár being, as a rule, purer than that of the United Provinces is in greater demand. **Dr. Buchanan Hamilton** in 1809 drew attention to this circumstance by his having pointed out that the *Patna-khari* was the best procurable in India. According to **U. C. Dutt** this was known to the recent Sanskrit writers under the name of *Ksh ári lávana* and was used medicinally in combination with other saline substances. As manufactured in India it is an impure salt but may be employed as a medicine for horses and cattle.

Medicine.

ALKALINE EARTHS. (*Conf. with Alkalis.*)

ALKALINE EARTHS.—Having now discussed the true alkalis and their salts with as much detail as the available space will admit of, it becomes necessary to record the chief facts known regarding the *Alkaline Earths* and their salts as met with in India.

BARYTA.

4. **BARIUM and BARYTA.**—The oxide of this metal (baryta) is an extremely caustic, poisonous and strongly alkaline substance that forms a hydrate with water. (*A*) **Barium Carbonate.**—This is imported into India to a very limited extent. It is highly poisonous. In Europe it is employed as an ingredient in certain forms of pottery and glass-ware and is the basis of certain delicate colours. In France it is used in the defecation of beet root sugar in place of lime. (*Conf. The Mineral Industry*, 1900, pages 53-54.) (*B*) **Barium Nitrate.**—This is obtained by decomposing the carbonate by means of nitric acid. It is the chief salt employed in pyrotechny for the production of green fires. It is also the tinctorial principle in BARYTA GREEN—a pigment of some value. Recently barium nitrate has been substituted for saltpetre in the preparation of certain explosives. (*C*) **Barium Sulphate.**—This is the most important of the barium salts and is known as BARITES (BARYTES) or HEAVY-SPAR. It is found in mineral lodes and usually constitutes a distinct portion of the gangue there present. In the Karnúl District, Madras, it occurs along witn galena, within veins of quartz. If ever worked large supplies could be obtained from that locality. So in the same way barytes exists in the Central Provinces in association with copper such as at Jabalpur and in the Rewá State. In Rájputána barytes has been reported by **Dr. Irvine** as occurring at the lead mines of Taragarh in Ajmir. In the Panjáb it has also been found in association with galena at Subáthu in the Simla District. While it would thus appear that the Indian sources of this alkaline earth have not been worked, barium sulphate is nevertheless available in every bazar and seems to be very largely sold as "white lead" or in adulteration of that

Carbonate of Barum.

Used in Pottery.

Defecation of Beet-sugar.

Nitrate of Barium. Baryta Saltpetre.

Green Flames.

Baryta Green.

Sulphate of Barium. Barytes.

Occurrence in India.

Adulteration with White-lead.

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substance. The reader will find an example of the extent to which this sulphate is employed in India by consulting the account given of the Afridi Wax-cloth industry under *CARTHAMUS OXYACANTHA.* Barytes is also used by the paper-makers and to a limited extent as a cheap substitute for barium nitrate in certain forms of fireworks. BARYTA. *Conf.* Agricultural Ledger No. 12 of 1901. Used by the Paper-makers.

5. **CALCIUM and LIME.**—*LIME* does not exist naturally, but in the form of the carbonate, it constitutes a by no means insignificant portion of the earth's crust, *e.g.*, limestone rocks. *LIME-BURNING* is the operation of driving off carbonic acid from the carbonate with the production of the oxide of calcium or *QUICKLIME.* This readily absorbs water and becomes *SLAKED LIME* or hydrate of lime. LIME. Lime burning. Quicklime. Slaked lime.

Carbonate of Lime; (*Dict. Econ. Prod., Vol. II.,142-152, V., 185-86*). This is known in India by an extensive series of names that denote both the conditions (quicklime, slaked-lime, etc.), and the source (limestone, marble, chalk, shells, etc.). The most general name may be said to the Hindustani *Chúná* a word which in the various languages of India assumes numerous forms such as *Churna, chúnáh, chún, chúno, chúnak, chúnámbu, shunnambu, sunnam, sunna, hunna, hunu,* etc. Its most general name in Sanskrit would appear to be *Sankha bhasma,* but certain writers give also *chúrná,* (=a "powder"), *sudha kapardaka-bhasma, sukti-bhasma,* etc. Its Arabic names appear to be *Kils* and *ahu* and its Persian *Nurkah* and *ahak.* Carbonate. Vernacular Names.

The word *chúnám,* by modern usage generally denotes the beautiful plaster or cement characteristic of many localities of India (more especially of South India); see below in the paragraph devoted to cements. One of the earliest European writers to use the word *chúna* appears to have been Garcia de Orta (A. D. 1563), although fifty years previously the Italian Traveller Varthema described the people around Calicut as eating betel leaves along with a certain lime made from oyster shells which they call "Cionama." Chunam. Edible Lime.

CHALK is very generally known as *Khari-matti* or *kharya-mitti.* Unslaked or quicklime is *Kali-ka-chuna* or simply *kali* or *kalai:* limestone is *Kalai-ka-pattar;* quicklime is often called *Ahak;* lime from shells is *Sipi-ka-chuna,* the lime from limestone being *Kattal-ka-chuna;* marble is *Marmar;* fossil corals are *Sang-i-yahada.* Chalk.

Sources.—There may in India be said to be three great groups of rocks or materials that afford lime; (*a*) limestone or marble; (*b*) concretionary lime (*Kankar*) found in the ground; (*c*) Marine and Land Shells; also coral reefs. Sources.

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ALKALIS.

Alkalis, Alkaline Earths, Alkaline Ashes, etc.

LIMESTONE AND MARBLE.

(*a*) **Limestone, Dolomite and Marble.**—It may be said that hardly any known geological formation in India is wholely without limestone in some form, although many of the examples are exceedingly impure and hardly worthy of the name. The best known marbles are those of Jodhpur (Makrána) and of Jaipur (Raialo), in Rájputána and of Jabulpur, in the Central Provinces. Within a radius of eight miles around Makrana there are something like one hundred quarries but of those only 15 are at present worked. These vary in depth from 30 to 75 feet and follow the vein. The marble is excavated by blasting, and is then cut into the required size by steel saws. It is hauled to the surface on wooden rollers and manual labour. The quality of the stone is generally better according to the depth it is worked but owing to the crude appliances used for hoisting to the surface, deep mines are impossible. The dust and fragments produced during mining operations at Makrana are burnt into lime and this quality is much appreciated for the finer kinds of plastering.

Best known. Marbles.

Makrána.

The white marbles of Raialo are much appreciated for filagree screens (*jáli*) of which numerous fine examples exist at Abu, Agra, Ahmadábád, Delhi, etc. The black marble found at Bainslana is used for statues, toys, etc. The blue and pink marbles of Narwár in Kishengarh State are much admired and largely used for ornamental purposes.

Raialo.

Ball, in his *Economic Geology*, has the following passage regarding Jabalpur marble:—"Except locally, in some temples, this marble has not been used for building purposes. The beds are much jointed and crushed by the disturbance, which has tilted them into their present vertical position and by certain trap dykes which traverse them. But it seems probable large unflawed blocks might be obtained; one which was sent to the first Paris Exhibition was said to be equal to Italian marble for statuary purposes."

Jabalpur.

In Burma there is an inexhaustible supply of lime such as limestone, raised coral reefs and marble. The beautiful semi-transparent white marble so extensively used for the figures of Gautama is obtained chiefly from the Tsygen hills in the Madeya sub-division of the Mandalay district.

Burma.

Marbles for Idols.

Space cannot be afforded to refer more than by name to a few of the other numerous qualities of limestone and marble met with in India. Some are of nearly equal merit to those already specialised and still others gradually decline until they have to be characterised as at most only good building limestones. The limestones procurable

Inferior Marbles.

Building

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Alkalis, Alkaline Earths, Alkaline Ashes, etc. (*G. Watt.*) **ALKALIS.**

LIMESTONE AND MARBLE.

in many parts of Bombay and Sind, for example, are admirable building stones though marble nowhere exists. The Porbandar miliolite and the great sandstones of Dhangadra are perhaps the best known. The former has been conveyed from Káthiáwár to Bombay and even to Calcutta and is employed in the construction of some of the more important of the recent buildings of these cities. In South India it may be said that crystalline limestones occur in Trichinopoly and Coimbatore, but of very inferior quality; good building limestones are found in Cuddapah, Karnúl and Guntúr, and marbles at Palnad. In the Central Provinces there are numerous examples of limestones and admirable building stones, such as those of Wardha, Nágpur, of the Vindhyan formation such as the limestones of Katni, and in the United Provinces the crystalline limestone of Mirzápur, which occur in the metamorphic rocks of that district. In various localities of the Panjáb good limestones and even marbles are found. Lastly a reference is essential to the limestones of Lakhimpur and of the Khásia and Jaintia Hills of Assam.

Porbandar Miliolite. **Katni.** **Mirzapur.** **Assam.**

This brief indication of some of the more important marbles and limestones of India may now be fittingly concluded by the following passage contributed originally to the *Dict. of Economic Products* by Mr. H. B. Medlicott :—

Sources of Lime.

"Lime is a scarce article in many parts of India. Much of the lime used in Calcutta is carried many hundred miles by river and railway. The want of a pure limestone flux at moderate cost has been the chief difficulty in working the iron furnaces in the Raniganj coal field. The most general source of building lime in India is *kankar* or *kunkur* (meaning gravel), a granular or nodular stone found on the surface and in the sub-soil. It is purely of secondary origin, being formed on the spot by the evaporation of the ground-water, containing in solution more or less of carbonate of lime produced in the slow process of soil formation by the general decomposition of rock-particles. The production of it is very much a matter of climate, by alternating period of soaking moisture and extreme dryness. Where this latter condition is most pronounced, as in North-Western India, the lumps of *kankar* often coalesce into a continuous mass, fit for use as building stone. A stone so formed must of course be impure and variable in quality, as to the quantity and nature of foreign matter according to the texture and composition of the bed in which the concentration of the lime is effected, but when these are favourable an excellent hydraulic lime is the result.

Formation of Kankar.

Limestones.

"Limestone is, however, of widespread occurence throughout British India, but as a rule the available deposits are at a distance from the

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ALKALIS. **Alkalis, Alkaline Earths, Alkaline Ashes, etc.**

LIMESTONE AND MARBLE.

centres of demand, and consequently the price of lime rules high. The most important sources, commercially, are :—

" *1st. Katni.*—in the Jabulpur District; supplies a lime of excellent quality, which is carried as far as Calcutta (737 miles distant), and forms a large proportion of the lime used in that city.

" *2nd. Sylhet.*—Along the southern foot of the Sylhet hills there is an inexhaustible supply of lime in the limestone of the nummulitic series, which formerly supplied the whole of the demand of Calcutta and Lower Bengal, and still does so to a large extent.

" *3rd. Rhotasgarh.*—The lower Vindhyan limestone near Rhotasgarh is quarried to a small extent and exported down the Són in boats; it was largely used in the works of the Són Canal.

" *4th. Himalayas.*—Along the foot of the Himalayas, boulders of limestone are collected and burnt in large quantities every year; the slaked lime is exported on camels, and supplies a large portion of the Punjab, and the North-Western Provinces.

" *5th. Andamans.*—There is a band of cream-coloured marble near Port Blair which may prove of economic importance, as it is at about the same distance from Calcutta as Katni, and the lime is of equally good quality.

" *6th. Other Localities* where limestone is known are numerous, but at present of merely local importance, or in most cases of no value whatever. A full list of them as far as they are known, will be found in the *Manual of the Geology of India, Vol. III., p., 449, et. seq.*"

KANKAR.

(*b*) **Kankar or Concretionary Lime.**—In the passage just quoted Medlicott has explained the formation of this substance. In the vast majority of cases a layer of *kankar* will be found to underlie *úsar* soils. This circumstance has purposely not been alluded to in the passage that deals with *réh* efflorescence because, although doubtless formed by the same physical forces, *réh* and lime have not been shown to be dependent on each other. *Réh* efflorescence may occur without any formation of *kankar* and conversely *kankar* may exist within the soil without any evidence of *réh* efflorescence or even of an abnormal deposition of soluble alkalis, see page 119.

Position of Kankar.

Uses.

This is the chief source of lime in Upper India and it yields an excellent and somewhat hydraulic lime. Mr. James Cleghorn (*Indian and Eastern Engineer, June 1898, pages 356-57*) gives the results of his study of this substance and of its practical utilisation as mortar. Very often the nodules of *kankar* are so abundant, at certain depths below the surface of the ground, that they become consolidated into block. Such blocks when obtainable are largely employed for building purposes and were so used extensively in the

Hydraulic Lime.

Block Kankar.

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KANKAR.

Ganges Canal Works. *Kankar*, broken and hammered while water is poured over, is the material mainly used for road-making in the greater part of India. This circumstance gives at once a vivid conception of the abundance and extensive distribution of the substance. *Kankar* has been tried as a flux for iron on several occasions, but with very indifferent results. Its composition is too uncertain and its liability to adulteration too great to admit of its use, except where limestones are not available.

Road-making.

Flux for Iron.

SHELL LIME.

(*c*) **Shell and Coral Lime.**—All over India shells are burned for lime. Away in the interior of the country wherever annual inundation occurs, a marvellous crop of exceptionally large land shells furnishes an abundant supply for most local necessities. In the Murshidábád District for example the following shells are so employed:—*Unio marginalis, U. flavidens* and *Ampularia globosa.* On the coast tracts of India and Burma, immense beds of marine shells and of raised coral reefs are met with. These are regularly utilised as sources of lime, and in South India have mainly given birth to the prosperous industry of Portland Cement manufacture—an industry that I understand is likely to be very shortly organised near the mouth of the Ganges, where rich beds of marine shells are abundant.

USES OF LIME.

Industrial Uses of Lime.—Limestone and Marble. Lime is universally present in the ash of all plants. As a manure it plays an important part, especially for soils rich in organic matter. For a similar reason lime is largely employed as a deodorising agent: it hastens decomposition of both animal and vegetable matter and absorbs noxious effluvia. In the form of chloride of lime (*BLEACHING POWDER*) it was at one time largely employed as a disinfectant. For that purpose it has, however, been considerably displaced by more effectual and less objectionable substances such as carbolic acid. As a bleaching re-agent chloride of lime is extensively employed, such for example as in the raising of metallic colours, in discharging Turkey reds, in calico-printing, etc. In India it is made into a resist paste with ordinary gum arabic and in that form is utilized by the calico-printers. Lime in some form is in fact extensively used in the dyeing and tanning industries. It is for example nearly universally employed by the Native manufacturers of indigo. Along with sugar it is added to the dyer's indigo vat in order to assist in the production of white-indigo. The carbonate of lime is used as an oil paint for in-door work and as a water colour mixed with gelatine. The Afridi wax-cloth workers add lime to their *roghan* to reduce its liquid condition and make it dry readily. The tanner utilizes it to remove the hair from hides. It, at the same time, also

Plant Food.

Manure.

Deodorising Agent.

Bleaching Powder.

Calico-printing.

Lime with indigo.

Paint.

Afridi Wax-cloth.

Tanning.

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ALKALIS. **Alkalis, Alkaline Earths, Alkaline Ashes, etc.**

USES OF LIME.

Soap and Candle making.

greatly improves the hides by softening their texture. Lime is of the greatest importance to both the soap and the candle makers, and it is necessary as a flux for iron smelting.

Pan.

Food and Medicine.—As an article of (what might be called) food, it is largely used by the people of India. In other words it is an essential ingredient in the preparation known as *pán*. The lime obtained from shells is objected to, however, for that purpose, by certain Hindus, on the ground that it is derived from animals. For medicinal purposes, lime enjoys a well recognised position, more especially as the basis of the mild antacid known as "lime water." It is used in the defecation of the saccharine juice obtained from beet-root. The coagulation of the nitrogenous matter, by boiling, is less perfectly accomplished in the case of beet than of cane juice. The addition of slaked lime accordingly greatly facilitates that result by the formation of insoluble lime compounds.

Lime water.

Defecation of Sugar.

Mortar.

Mortar and Cement.—(*Dict. Econ. Prod., II., 245*).—By far the most important use of lime is as mortar—a cement which consists of lime, sand and water. If lime be mixed with water, a paste is formed that will rapidly harden or "set" as it is called. When dry it will, however, be found to crack and crumble to pieces. To prevent this it is mixed with sand (or in India with the fine powder made from bricks known as *surkhi*). To obviate a too rapid absorption of water from the mortar, it is customary to moisten the stones or bricks, when a much more durable cement is the result. If mortar be properly prepared a thin layer will be found sufficient to bind together the materials with which it is mixed.

CEMENTS.

There are commonly said to be the following classes of cements:—(*a*) CALCAREOUS; (*b*) GELATINOUS; (*c*) GLUTINOUS; (*d*) RESINOUS; (*e*) MIXED MATERIALS but Non-resinous. The first mentioned are those with which the present article is more immediately concerned such, for example, as the mortar already indicated. A hydraulic cement or Portland cement as it is called, is in other words a cement which has the property of setting under water. This is obtainable from certain limestones that naturally contain from 10 to 25 per cent. of alumina, magnesia and silica, or it may be artificially manufactured by mixing 65 to 80 parts of chalk or other pure lime, with 20 to 35 parts of river mud or clay, and a little oxide of iron, say 3—14 per cent. These ingredients are thoroughly mixed in water, dried slowly, calcined and then reduced to a powder. In India Portland cement is at present mainly manufactured in the Madras Presidency but in other Provinces it is occasionally prepared and chiefly from argillaceous *kankar* to which a certain proportion of fat limestone is added. But it is a striking peculiarity of these hydraulic

Portland Cement.

Indian Production.

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USES OF LIME CEMENTS.

cements that their adhesive power is diminished by mixture with sand. If used as a stucco the sand employed must be perfectly free from loam and the surface must not be painted over (if that be so desired) until the cement has been thoroughly dry say for some months.

Magnesian Cements.

It may further be added that if Portland cements have more than 4 per cent. magnesia they rapidly decompose when kept under water. A cement with a basis of white magnesia in place of clay, is sometimes known as "White Mortar." There are large deposits of magnesite and of magnesium limestones (dolomites) especially near Salem) in South India and these it is understood have recently been taken advantage of by the Madras Portland Cement Company in the preparation of a cheap, easily applied and rapidly drying plaster that takes a fine polish. This I understand is being made both at Bangalore and Calicut. Mr. C. S. Middlemiss wrote in 1896 a most interesting report on the magnesite areas of the Chalk Hills near Salem. (See *The Agricultural Ledger No. 15 of 1896.*) A paper written by Mr. James Cleghorn, *Indian and Eastern Engineer, May 1894, pages 320-321*) will also be found to contain much useful information regarding magnesian cements. Regarding the industry in the United States of America consult *The Mineral Industry*, 1900, pages 75-82.

Polishing Cement.

Mention has already been incidentally made to the fact that an admirable polishing and exceedingly strong cement (sometimes spoken of as *chúnám*) is made in various parts of India. There are methods of preparing this substance, but these all practically agree in the circumstance that some saccharine substance or other is combined with the lime. The substance most commonly employed for this purpose is the jaggery obtained from the cocoa-nut palm. The milk of that palm is also mixed with lime in the preparation of a very superior white-wash.

Special Cements.

Lime or some of its salt (such as plaster of paris) is largely employed in combination with glutinous and resinous materials in the formation of cements. The gluten of rice is in India commonly mixed with a certain percentage of pure lime in the preparation of a strong cement which is employed to join the various parts of musical instrument in place of glue. Instead of rice gluten the dough of fine flour may be kneaded in water until gluten only remains. To this should than be added a small quantity of pure lime. The cement thus prepared is largely used for all forms of wood-work and has the special merit of resisting damp. It is generally known by the name *suji*. Lac combined with borax forms a convenient cement to be used where exposure to water or moisture is unavoidable. Cutlers'

Suji Cement.

Lac Cement.

ALKALIS.

Alkalis, Alkaline Earths, Alkaline Ashes, etc.

USES OF LIME. CEMENTS. Ingredients.

cement consists of rosin, bees'-wax and brick-dust or plaster of paris, or simply rosin and plaster of paris.

Cement Materials.—The following substances are mentioned as being specially used in India in combination with lime, in the preparation of special cements:—

1. **Adenanthera pavonina**—seeds.
2. **Ægle Marmelos**—glutinous matter of wild fruits.
3. **Borassus flabellifer**—juice.
4. **Cocos nucifera**—jaggery, (crude sugar) and also the milk of the fruit.
5. **Commiphora Agallocha**—the gum resin.
6. **Oryza sativa**—the gluten of rice.
7. **Sugar**—*Gur*.
8. **Triticum vulgare**—the gluten of wheat.
9. **Typha angustifolia**—the down from ripe fruits.

For further information see *Cements* in the *Scientific American Cyclopædia of Receipts, Notes and Queries, by* Albert A. Hopkins *pp.* 67-90.

MARBLE WORKS.

Marble.—Is extensively employed in the decoration of palaces, temples and mosques, and in the construction of idols, ornaments, toys, etc. Perhaps one of the most pleasing and at the same time surprising features of Indian architecture might be said to be the marvellous filigree screen (*jali*) in sandstone or marble that take the place of the glass windows of European buildings. Keene (*Stone Industries of Agra*) gives a very accurate and impressive account of the screens at Fatehpur Sikri (constructed, 1581 A.D.). "The outer screens" he says "are so minutely pierced that they actually look like lace at a distance and illuminate the mortuary chamber with a solemn half-light which resembles nothing else that I have seen." Colonel T. H. Hendley, C.I.E., discusses the uses of marble in Rájputána in the following passages:—"Jaipur supplies most of Brahmanical India with its idols in white marble, plain or coloured and gilt; in red or black marble." "The purest white marble is brought from Makrána, a short distance from the Jodhpur side of the Shambhar Lake, but a much-liked white marble, often veined with blue, of a cheaper kind, is obtained from Raialo on the Alwar border, and is especially worked at Dausa. The stonemasons prepare in the summer enormous stocks of images which are brought by the brokers from Gujarát (Bombay) and elsewhere after the rains and then sold by retail in the winter. The Makrána marble is worked at Jaipur, though sometimes very large idols are roughly hewn at the quarries to lessen expense of carriage. Baldeogarh on the Alwar border yields black marble, of which figures of animals, besides great idols, are made. The red marble from the same place is usually cut into the forms of camels and plates. All these marbles are employed in architecture, and in addition of late, green marbles from Ajmir. The boys learn to carve

Screens *Jali.*

Brahmanical Idols.

White Marble.

Black Marble.

Ornaments and Toys.

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MARBLE.

by making small images from soapstone. These sell readily among the poor."

Inlaid Marble.

In Agra a fairly extensive industry exists in the preparation of screens, tables, fancy boxes, picture frames, plates, vases, etc., as also models of the Taj and other ancient monuments. These are mostly done in white marble inlaid with agate, carbuncle, carnelian, chalcedony, jade, jasper, lapis lazuli, topaz, turquoise and even with bloodstone, garnets, rubies, sapphires, etc. This art is supposed to have originated with the Taj (A.D. 1627-1658) and to have gradually declined until at the beginning of the 19th century it had disappeared. It is said to have been revived by Dr. J. Murray about 50 years later. It has flourished ever since, the goods produced in Agra being carried for sale by the traders in Indian artwares all over India.

GYPSUM.

(B) **GYPSUM, PLASTER of PARIS** and **SULPHATE OF LIME**, *Dict. of Econ. Prod., IV., pp. 195-97.*—This is the hydrous calcium sulphate which, when it occurs in an amorphous state, is called *GYPSUM*; when in a more massive condition is *ALABASTER*; and when in transparent crystals is *SELENITE.* On being calcined it parts with its water and then constitutes *PLASTER OF PARIS.* The powder thus produced on addition of water gradually sets and as it does so expands slightly. It is this property that has made *PLASTER OF PARIS* so exceedingly valuable for making casts and moulds. In India it is known by an extensive series of names such as *Kulnar, kurpúra-silasit, kársi, sang-i-jeráhat, surma safed, makol, jirah, etc.* Plaster of paris is generally called as *Gach.*

Alabaster. Selenite. Plaster of paris. Vernacular Names.

Madras.

Occurrence.—In the *Madras Presidency* it has been met with abundantly, but in an impure form, in the cretaceous rocks of Trichinopoly. Masses of gypsum and crystals of selenite are occasionally found in the clays of Chingleput. In Nellore crystals of greater purity than those found near Madrás have been recorded as fairly prevalent.

Bombay.

In *Bombay* selenite occurs in the marine deposits about Bombay and in Káthiáwár and in some parts of the Deccan. Very excellent gypsum is found in Cutch. In *Sind* deposits frequently 3 to 4 feet thick occur near the top of the Gajbeds of the Kirthar range. The Mud Gorge on the Harnai route to Quetta owes its intractable character to the circumstance that much sulphate of lime is there present and very largely in the anhydrite condition. This absorbs water and thereby expands 33 per cent. The adjacent materials are in consequence continuously displaced and the Mud Gorge may, therefore, be said to be in a state of constant change.

Sind. Baluchistan.

Rajputana.

In *Rájputána,* at Nagor in Jodhpur, a bed of gypsum probably not less than 5 feet thick has been worked to some extent. It is not

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ALKALIS. **Alkalis, Alkaline Earths, Alkaline Ashes, etc.**

GYPSUM.

as a rule of good quality and is mined in a very crude fashion. While excavating a well at Falod, gypsum of a very pure quality was found but at too great a depth to be of much value.

Punjab.

In the *Panjáb* (Bannu District) the mineral is found in Kálabágh and in Khasor but not utilized. The Kohát District contains gypsum in great abundance. Ball says "It might be obtained by open quarrying in any quantity but is not worked." The Salt Range possesses gypsum in enormous quantity associated with rock salt. The Spiti Valley contains gypsum of snowy whiteness.

United Provinces and Oudh.

In the *United Provinces,* deposits of gypsum have been reported as met with in Dehra Dun, Kumaun and Garhwál. Mr. C. S. Middlemiss (*Records Geological Survey, XXII, Pt. 2, 1889*) gives a full account of the gypsum of Nehal Nuddi in Kumaun. The "*Pioneer*" (*July 27th 1888*) announced that gypsum had been found at a locality some 19 miles distant from Haldwani, a station on the Rohilkhand and Kumaun Railway.

Burma

In *Burma* gypsum has been found but not in quantity to be of much commercial importance.

USES.

Manure.

Industrial and Agricultural Uses.—For a great many years gypsum has been regarded as a *manure* of exceptional merit especially for leguminous crops and for certain soils. It has recently been found to vastly increase the yield of indigo so that a large demand seems likely to arise for gypsum. The reader should consult the observations already made (Page 120) regarding the use of this salt in destroying injurious alkalis and at the same time so modifying the physical conditions of the soil as to bring it into a culturable state. Gypsum might be viewed as an important constituent in the much admired manure known as "Superphosphates"—a manure that might be briefly described as prepared by the treatment of phosphatic minerals with sulphuric acid.

For Indigo.

For Reh.

Superphosphates.

Plaster of paris.

The next most important use for gypsum may be said to be the numerous methods of utilising plaster of paris. In 1852 Dr. Buist drew attention to the interesting fact that the Natives of Sind had, from ancient times, been in the habit of casting lattices and open-work screens to be used within houses to allow of free circulation of air. The Marwaris very cleverly make what might be called stained glass windows by taking two lattice screens, made of plaster of paris and of identical pattern, and placing between these fragments of coloured glass so arranged as to bring out the desired colour design. The screens are then firmly fastened together and the fragments of glass secured in their positions by a thin layer of liquid plaster being run over the lattice upon which the glasses have been arranged before pressing home on the top the second lattice.

Lattice Work.

Coloured Glass Work.

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Alkalis, Alkaline Earths, Alkaline Ashes, etc. (G. Watt.) ALKALIS

GYPSUM.

Arabesque Ceilings.

In many parts of Rajputana and of the Punjab the walls and ceilings of palaces are richly ornamented, in arabesque design, by fragments of glass. These are silvered behind or backed with plated metal discs or with coloured tinfoil or they are painted on the surface and imbedded singly or collectively in wooden frames, within a plaster which consists mainly, if not entirely, of plaster of paris. This work might be described as a kind of mosaic and from the fact of pieces of glass (*shishâh*) being used has come to be spoken of as shish-mosaic. The famous *Shish-mahal* (the Palace of Glass) at Agra, the *Shish-mahal* at Lahore and the *Shish-mahal* in the ruined city of Amber (near Jaipur) are perhaps the best examples of this class of work. **Mr. Kipling** very truly says "The effect of the *shish* or mirror mosaic, though brilliant, narrowly escapes the charge of vulgarity," so that it is not much to be regretted that the art may be said to be hardly practised at the present day. **Dr. Fleming** in his *"Account of the Salt Range,"* says the Natives use plaster of paris mixed with pure lime to produce their finest qualities of shining marble-like *chúnám*. *PLASTER OF PARIS* is also largely employed as a white-wash.

Shish-mahal.

While it would thus seem that certain uses of plaster of paris have been well known to the Natives of India, for a considerable period at all events, a knowledge in the art of casting figures, ornaments and toys in that material would seem to be of comparatively recent date and to have originated with the Schools of Art. So late as 1885, while engaged supervising the preparation of life-sized statues or models of ethnological subjects that were required for the Colonial and Indian Exhibition, I experienced the greatest possible difficulty in inducing the Krishnagar modellers to substitute plaster of paris for clay. I procured a railway wagon load of gypsum from the Salt Range, had it fired in Calcutta and found that it yielded a most excellent modelling plaster and at a cheaper rate than I could purchase the imported article, which alone was then procurable in Calcutta. But my clay modellers struck work and I had to import others from Lucknow before I could induce the Krishnagar men to resume work. I mention this circumstance as showing the quality of the Indian plaster of paris.

Plaster of paris Casts.

Modelling.

Alabaster where met with is largely utilized in the manufacture of ornaments and toys. The dark green form procured from Garhwál is regularly made into elegant cups and saucers and even large bowls that are much admired by the richer Native gentlemen of Northern India. The same material, drawn from various sources, is to some extent utilized by the stone carvers in Agra and other centres of that industry. To a very small extent gypsum is used as cooling medicine in fever and when burned into plaster of paris it is sometimes employed as a substitute for lime in *pán*.

Alabaster Toys.

Medicine.

Food.

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STRONTIUM. Production.

Celestite.

Sugar Refining. Strontianite.

Red Fire.

6. **STRONTIUM and STRONTIA.**—The oxide strontia does not exist in nature, but it may be produced by burning either the carbonate or the sulphate. ***Celestite,*** the sulphate of strontium, has been reported as met with in two localities in India, *viz.*, in the Kirthar limestones of Sind and in the red clays of Surdag in the Salt Range. In the sugar refineries of the Continent of Europe the native carbonate ***(Strontianite)*** was formerly used in place of lime. (*Journal Soc. Chem. Industry, Nov. 1901, p. 1092.*) But this metal is chiefly known in India in the form of the imported nitrate which is largely employed in the preparation of red coloured flames in fireworks.

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THE

AGRICULTURAL LEDGER.

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(Vegetable Product Series, No. 71.)

THE AGRICULTURAL LEDGER.

1902—No. 6.

ÆSCHYNOMENE SP.

(SOLA.)

[*Dictionary of Economic Products, Vol. I., Æ. 559—65.*]

THE SOLA-PITH PLANT:

A REVIEW OF EXISTING INFORMATION.

By DR. GEORGE WATT, M.B., C.M., F.L.S., C.I.E.

TRUE SOLA PLANT.

ÆSCHYNOMENE ASPERA, *Linn.; (Fl. Br. Ind., II., 152).* This is the *Shola* of Hindustani or as it is pronounced in Bengal the *Sola*—a word which has been still further corrupted into SOLAR by English writers and manufacturers. In order to distinguish this from the next species it is often designated in the various districts of Bengal and Assam as the *Bhát* (white or rice-like) *sola* or the *phul* (flower or soft) *sola*. It is also known in the other provinces by the following names:—*Korhela, kodhila, kathua, kurdhela, fulkurdhela, khokhri, khakhra, kuhila* (or *pani*=water-*kuhila*), *shupra* or *hupra, botla, bhida, dhendas, dhendar pola, soal, sul, pangasaver* or *siver, dhendor, kagdia, jiluga bendu, jiluga, atunete, takke, suddai kirai, benda, pau-bin, thaw, thaung, etc.*

An Aquatic weed.

Habitat.—A floating bush, with sensitive leaves, found on land annually inundated or within the margins of tanks or lakes; throughout Bengal, the greater part of Assam, frequent in Burma and also present in South India, but represented in the other provinces by the next species.

CULTIVATION Season Nov.—Dec.

Cultivation: Season.—It is not systematically cultivated but, after removal of the stems, in November and December, the upper portions with ripening pods are thrown on the water where they float until the seeds are self sown. The roots are also perennial and

CULTIVATION.

produce an annual crop of shoots. These begin to appear in April and May, the flowers set about August and September and by February and March the pods are ripe and the pith-yielding shoots over-ripe. If left until the seeds mature the stem becomes dry, shrinks, discolours and a large cavern forms along the centre, which corresponds with the true or theoretical pith. While the *sola* can exist on the banks of tanks or lakes, above water level, it becomes reed-like, the shoots are then rarely thicker than the little finger and the plant is apparently unhealthy. It is essentially an aquatic species and normally grows in from 2 to 4 or 6 feet of water; the stem below swells greatly, in the middle third (it becomes perhaps 2 inches in diameter), in the lower third it tapers towards the roots or muddy bottom of the swamp, and in the upper third towards the portion that rises above the water level. It often grows in corners of rice fields and, where a demand exists for the pith, becomes a source of revenue and is thus more or less protected. Usually, however, it is viewed as a pernicious weed and is accordingly uprooted. It may generally be accepted as indicating the deeper portions of the fields—those that retain water more or less throughout the year.

Stem Shrinks. Swamp Cultivation. Appearance in Rice Fields.

MANUFACTURES. PITH WORKERS.

Pith Manufactures.—In Bengal and Assam the workers in pith as a rule belong to the Hindu caste of garland-makers, the Malakars or Malis. They have usually acquired the exclusive and hereditary right to manufacture the garlands and decorations required by the families of a certain locality for marriages, festivals and religious ceremonials. The stems are cut into lengths of two or three feet—only the thicker portions being selected—and tied into bundles. After being stored until quite dry, the brown bark is first removed and the pith thereafter cut up in various ways according to the necessities of the article for which it is required. If, for example, intended for the manufacture of hats, caps or frames of pugries, it is split into thin sheets. For this purpose the stem is held in front of the operator and with a long sharp thin knife is stripped spirally, the knife being made to travel round and round within the thickness, until the whole stem is reduced to a sheet not much thicker than note paper. To perform this feat expeditiously requires great skill, since the slightest excess pressure will compress the pith and produce inequalities in thickness or sever the sheet into useless pieces. Hats, etc., are worked up on wooden or clay moulds of the required shape and size and, if honestly made, are built up layer upon layer of *sola* sheets, pasted one on the top of the other. By dishonest makers a large proportion of paper is intermixed with the pith thus adding greatly to the weight of the hat and lessening very materially its

Hat Making.

MANUFACTURES.

insulating power (to the rays of the sun)—the property which makes the *SOLA-TOPI* superior to hats made of felt, cork or any other known material in the hat trade. In Assam the idols of *Mandsa* (*Monosa*, the Snake goddess) are made of pith: similarly in some parts of Bengal both Hindus and Muhammadans, during the month of August, worship a *sola*-pith idol.

FLOWER MANUFACTURE.

If the pith be required for the manufacture of flowers or to be woven into mats, the debarked stalks are drawn between bamboos, fastened upright in the ground at various distances apart, or are flattened by means of smooth stones, a stone being firmly drawn over the top while the sola rests on a smooth stone floor. By either of these methods the pith is compressed and drawn out. It will retain the form thus given it until moistened, when it again expands. To make a flower the strips of sola are compressed in such a manner that in transverse section they are more or less triangular in shape and, along the surface corresponding to the base of the triangle, parallel lines are cut. To make a flower, strips of sola (prepared in the way indicated) are cut with a sharp knife transversely into very thin pieces. The pointed ends of the triangles are inserted into slits made on another stick of sola, intended as the stalk of the flower. When the required parts have been thus inserted into their places a brush, moistened in water (previously coloured green) is made to touch the outer whorl of triangles. These instantly expand and become the sepals of the rose or other flower. A brush, moistened in pink or other coloured water, next touches the inner whorls and these obeying the magician's wand expand into petals and are bent while still flaccid into the desired positions. The slits that were cut lengthwise along the compressed sticks of sola are now seen to open out into petaloid teeth. Stamens are formed of thin strips of pith, upon the extremities of which (from a coloured saccharine fluid) particles of sugar have been made to crystalise, thus forming glistening anthers. Floral buds are constructed of stained grains of rice fastened within green leaflets of sola. But to write a full account of all the simple and effective contrivances adopted by the pith-workers would occupy many pages. The few illustrations given must be accepted as denoting the high proficiency attained by these simple yet artistic artificers.

Compression of Pith.

Swell when moistened.

Stamens or Buds.

Centres of the Art.

The three great centres of this art may be said to be Dacca for camellia-like large flowers; Mandalay for graceful sprays of small flowers; and Tanjore for models, such as temples, carts, etc. But all over India the malakars are to be found making marriage crowns (the *Mukut* or *Topar* of Bengal, the *maur* of Behár and *murial* of Assam) for Hindu brides and bridegrooms; the *Sehra* or bridal veil

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MANUFACTURES.

or chaplet worn by Muhammadans; the decorations for idols such as the *Chhar, Jhulan* and *Rahan;* or the *Gerua* to be worn during the worship of *Satdeo;* as well as children's toys, such as crude artificial flowers, fruits, dolls, birds, etc., all contain sola or are entirely made of that substance.

Local Manufacture.

Sola as a Tinder.

Some quarter of a century ago sola held a much higher place in the domestic life of the people of India than at the present day. It was then in universal use as a tinder; a stick of sola burnt at one end was held in the hand alongside of a flint; by a stroke of the steel a spark was conveyed to the ashes of sola and could be instantly blown into flame. The introduction of matches may be said to have driven sola tinder from the homes of even the poorest inhabitants of India, but sola still finds a place as a useful and convenient cork for medicinal and other bottles and as plugs to widen the perforations made in the ears to admit of large and still larger earrings. It is made into bottle cases within which bottles or other vessels may be placed so as to keep water cool. It is employed to line the tops of palankins and thus prevent the penetration of the sun's rays and keep the interior cool. It is also used for the lining of seats and cushions such as elephant pads, and in Bardua village in Nowgong, Assam, it is even woven into sleeping mats or *kats* as they are designated. By the Muhammadans it is utilized as a lining to the more highly ornate *Taziyas* used at the Muharram.

Bottle cases.

Mats.

MEDICINE.

Medicinal.—In surgery a compressed and pointed piece of pith may be inserted into the opening of a sinus or abscess or the rigid os uteri. It rapidly absorbs moisture and expands, thus widening the opening. Flat pieces much compressed and with a circular hole in the middle may be similarly used as corn plasters.

CHEMISTRY.

Lignocellulose.

Chemical.—A long and interesting paper on the *Chemistry of Sola* by Hancock and Dahl will be found in *Chemical News of July 12th, 1895.* These authors show that the so-called pith is in reality the true wood of the plant and that the pith proper is the softer central core. They identify the so-called pith as a lignocellulose devoid of free aldehydic groups and characterised by colour reactions which show a close resemblance to the celluloses.

FOOD.

Pot-herb.

Food.—By way of concluding this summary of the information available regarding the sola plant, it may be said that the **leaves** are sometimes eaten as a **pot herb**. From Hoshangábád comes the information that an **oil** is extracted from the **seeds** and which is used in the treatment of cramp and pain in the side.

TRADE.

Trade.—There is practically only a local demand for SOLA-PITH and in its unmanufactured condition it is hardly if ever exported. The best quality is obtainable in Bengal and from there is carrried all

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over India. The manufacture of SOLA-TOPIS appears to have originated in Calcutta. The name *top* or *topi* is Hindustani in origin and occurs all over India. The expression TOPIWALA which was first very possibly given to the Portuguese, became in time applicable to all Europeans and simply means "hat-wearers." It was specialised at a much later date into the hats made of pith and, as suggested, these in all probablity first made their appearance in Bengal. To this day the centre of the trade may be said to be in Calcutta and, although all over India and even in Egypt and Europe, these hats may be purchased and bear the names of local makers, the bulk of the frames are made in Bengal and are exported in that condition to be covered and finished off by local traders. (*Fl. Br. Ind., II., 151.*)

TRADE. Sola-topis. A Calcutta Trade.

AE. INDICA, *Linn.*

ÆSCHYNOMENE INDICA.

Habitat.—This is a much less aquatic form than the preceding. It occurs throughout Behár, the United Provinces of Agra and Oudh, the Central Provinces, Berár, the Panjáb, Rájputána, Sind, Bombay and South India. It is also met with in Bengal, Assam, and Burma, but in these provinces always on the margins of canals and rivers, above water level, or in low-lying land that is but temporarily flooded. It is a taller, more bushy plant, than the preceding species and as a rule forms harder and more woody stems.

A Marsh Weed.

It is known by the following names:—*Kat* or *kath* (=hard) *sola*, *kukri*, *papri*, *khukhundi*, *kat-kurdhela*, *kothela*, *chauchi-sola*, *khukhri*, *bendu*, *tige-jiluga*, *mullu-jiluga*, etc. It is the *kuhila* of Assam generally, the *pani*-(=water) *kuhila* being the preceding species: it is the *kathia dhendor* of the Central Provinces, AE. *aspera* being the *kagdia-dhendor*. The *chirmilli* or *sirmilli* of these Provinces is prohably *Sesbania* and not *AEschynomene*.

Vernacular Names.

Manufactures.—These and such like names contrast this with the other species, the present being the hard *sola*. It is, however, used for most of the purposes to which the soft *sola* is put, though being harder it cannot be so easily cut nor made into such beautiful thin sheets. It is accordingly unsuited for flower-making; but at Sheikhpuri, a village in the Roorki District, a large trade has recently been developed in the manufacture of SOLA-TOPIS from this form of pith—a surface dressing only of Bengal-pith being given. The SOLA-TOPIS of Upper India are accordingly now very largely derived from Roorki. Being a cheaper form of pith it is also the quality most generally employed as floats for fishing nets, for fishing baskets (*khaloi*) and fishing rafts, and also for supports to persons who have to swim across large rivers, etc. It is believed, moreover, to be more durable in water than the soft sola. It is extensively utilized in making *gadis* or elephant pads. Since it is an abundant weed it is a useful fuel and has the reputation of being of special value in firing pottery. The

Manufactures. Roorki. Sola-topis. Floats. Padding for gadis. Fuel.

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ÆSCHYNOMENE INDICA. Gun-powder. Trade.

charcoal made of it is highly prized in the manufacture of gunpowder and fire-works.

Trade,—No information can at present be furnished on this subject, but it may be explained that the pith of *AE. indica* may be recognised by the circumstance that the stem is curiously striated on the thin bark and has wart-like formations along the striations. The central pith is always present in the form of a hollow surrounded by a slightly hardened layer. In *AE. aspera,* the bark is not striated, the stem, unless when over-ripe, is quite solid, very soft and of a pure white colour.

Distinctive Characterestics.

SOLA-SUBSTITUTES.

SOLA-SUBSTITUTES.—The following are the chief plants, and localities, where used, of the substitutes for *SOLA,* communicated to me in connection with the above mentioned correspondence :—

ARALIA ARMATA, *Seem.*, The *Bam-* (high land) *kuhila* of Sibsagar, Assam.

CASSIA MIMUSOIDES, *Linn.* (*Dict. Econ. Prod. II.,* 220). The *Bam-kuhila* of Jorhát, Assam.

Manipur Sola.

CEPHALANTHUS OCCIDENTALIS, *Linn,* The *Chonggang* of Manipur, Assam, used in the manufacture of flowers and other decorations.

Angami Naga Sola.

HEPTAPLEURUM HYPOLEUCUM, *Kurz.* (*Dict. Econ. Prod. IV.,* 222). This is the *Tirrhu* of the Angami Nagas, the pith of which is used in the construction of a girdle worn around the knot of hair and as the ear-ornaments donned during the cold season *gennas* or *pujas.* It is also employed in the construction of a sort of halo placed on the head during special occasions.

MIMOSA PUDICA, *Linn.*, (*Dict. Econ. Prod. V.,* 248). The *Lajoni* of Araria in Purnea, Bengal, used as floats.

PENTAPETES PHŒNICEA, *Linn.*—The *Kaya-sola* of Midnapur.

A Cheap Sola.

SESBANIA PALUDOSA, *Prain,* (*Dict. Econ. Prod. VI., Pt. II.,* 542). In many districts of Bengal, the United Provinces and the Central Provinces this bears the same vernacular names as have been given for Æschynomene indica more especially *kath-sola.* The pith of the two plants is certainly very much alike, only that the term *kath* or hard is even more appropriate to the present plant than to Æ. indica. It is the *Jainti* of Purnea, a district in which both plants grow abundantly and are separately distinguished. For all the ordinary purposes, such as floats, padding of elephant *gadis,* lining to palankins, etc , the pith of this plant may be used in place of the true sola.

SONNERATIA ACIDA, *Linn. f.*, (*Dict. Econ. Prod. VI. Pt. III.,* 275). The *Lama-paw* or *Nyan-tha-paw* the "inferior-wood-sola" as the last name denotes; the wood is often (in Rangoon) used in the manufacture of toys, etc., in place of sola.

Shan Sola.

TREVESIA PALMATA, *Vis.*—The *Maitang* of the Shans. Pith sometimes made into artificial flowers and other decorations for religious offerings and mostly in zig-zag patterns. Leaves boiled and eaten as a sort of soup.

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G. I. C. P. O.—No. 776 R. & A. D.—26-8-1902.—2,230.—C. M. W.

THE AGRICULTURAL LEDGER.

1903—No. 1.

IMPORTANCE of PRUNING.

deterioration of tea gardens and hence of the lack of permanence of tea properties.

Objects of Pruning.

2. ***Objects of Pruning.***—Pruning is an operation carried on in order to induce the plant to assume a particular shape so as to facilitate cultivation and plucking of the leaf, to increase the average yield of each plant, and to retain or improve the quality of tea produced. The bush must not be allowed to grow so high that the leaf is difficult to pluck, requiring two pluckers to pluck a bush which might be plucked by one in the same time if the bushes were a reasonable height, nor to spread itself so thickly that the amount of cultivation necessary—an amount varying with the position and nature of the soil—is unduly interfered with. Bushes badly pruned bear most irregularly, a year of over-bearing being followed by several of under-bearing, as a consequence of exhaustion caused by a too severe strain on the reserve forces of the plant.

Differences in practice.

3. ***Differences in practice.***—In spite of the radical importance of the subject, differences in practice are very great. Gardens lying side by side are treated by essentially different methods, and it says much for the hardy nature of the tea bush that so many of these seem to give very good results. It might perhaps, however, be suggested that in some cases where very good results have for a good many years been obtained, it has been *in spite of* a bad system of pruning, rather than by its aid.

Different methods necessary.

It must not be understood that we are prepared to recommend a uniform system of pruning for the whole of the tea districts. Nothing could be further from our purpose, and to attempt to do so would be to ignore differences in climate, in elevation, in type of plant, and in soil, which make tea planting in Darjeeling and Sylhet, in Dibrugarh and in Chittagong, in the Duars and in Chota-Nagpur, entirely different matters. But although differences in practice must exist, yet the principles underlying every system are the same, and it is to these principles we wish to draw attention in the present article.

THEORY of PRUNING.

II.—Theory of Pruning.

4. One of the ablest papers on the subject of the pruning of tea bushes was written by Sir George King as long ago as 1871 (*Journal Agri-Horticultural Society, Vol. III, Part I*). It seems

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desirable to give here a few passages from that paper which, it is feared, is not sufficiently well known by the planting community.

THEORY of PRUNING.

Production of flowers.

" Now the bearing of flowers and fruit," writes Sir George, " is the natural consummation of a plant's life, and the removal of these after they have been produced does no harm to the producing plant as an individual (on the contrary often benefits it), although the act affects its possible posterity. It is true that in order to force it to bear unnatural quantities of flowers and fruit, or flowers and fruit possessing unnatural qualities, the horticulturalist often exposes a plant to treatment which is injurious to it as an individual, and which leads to premature old age; at the same time it is treatment which, as regards flowers or fruit, is the most advantageous. In contrast to this is the action of the tea grower who, by the very collection of this crop, necessarily exposes his plants to treatment which, as regards a continuation of that crop, is disadvantageous."

Leaf crop disadvantageous.

European Experience.

" In the cultivation of almost all kinds of fruit trees, the operation of pruning holds a prominent place. The problems respectively presented to the European grower of fruit and flowers, and to the Indian cultivator of tea being different, it is only reasonable to expect that different methods of practising that operation would be advisable. The general practice of pruning as carried on by European gardeners is, however, founded for the most part, upon a knowledge of the principles of vegetable physiology, and it is therefore also reasonable to suppose that Indian tea growers might have learnt a good deal on the general subject of pruning from European writers on gardening even although not venturing to put their plantations under the charge of practical European gardeners with full powers to do as they might see best. Until within a year or two ago, however, the only kind of pruning attempted in the tea gardens of the North-West Provinces, was the removal of wood actually dead and the application on rare occasions of a hedge-clipping scissors, which delicate implement used to be entrusted to a native gardener *(mali)* with orders to reduce by its means certain bushes to a particular height, a stick of the required length being given to him as a measure. Indiscriminating treatment like this is the kind of pruning to which a few gardens in these provinces used now and then to be submitted. Rational pruning involves consideration and selection; and each bush ought to be treated according to its own individual condition, and not in accordance with a rule-of-thumb laid down for an entire field or garden. It is only certain stems and branches to which, as a rule, the knife can be applied with advantage, and these for the most part are the ones that afford the

Pruning to a fixed height.

Pruning for individual necessities.

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THEORY of PRUNING.

most marked examples of the natural effects of 'plucking.' Now, if we think of the matter for a little, the process of 'plucking' will be seen to be really of the nature of pruning, and to recommend pruning as a cure for the evils of plucking, may, therefore, appear paradoxical. To explain the seeming paradox, let us consider briefly the appearances presented by a young shoot of tea before it has been deprived by the plucker of its tip with the three or four leaves or leaf-buds borne thereon. Such a shoot bears on its entire length, let us say, ten leaves, and at the point where each leaf springs from the stem (*i.e.*, at the axil) there lies a small bud. Each of these buds is capable of development into a lateral branchlet. In a branch bearing as we have supposed ten leaves, it is not probable that, were things left to their natural course, each of the ten axillary buds would become developed into a natural branchlet. When, however, the growing point of the shoot is removed, these axillary buds are stimulated by the ascending sap, and most of them expand into lateral branchlets; and these being in turn topped by the plucker, their axillary buds are stimulated, though in a less degree, into expansion into branchlets, and so on. The vigour with which lateral branchlets follow on 'plucking' or topping the leaders, diminishes regularly with each repetition of the process until after a few years of such treatment a period of nearly complete stagnation is reached, and the original ten-leaved shoot with which we started presents the appearance of a tough greyish-barked and often gnarled stem, bearing at its top a dense collection of small wiry twigs, which carry a quantity of small thin tough leaves totally unfitted for manufacture into good tea. These twigs, moreover, are of such low vitality that when topped they hardly respond by throwing out fresh lateral shoots or 'flushes.' This is the kind of stem of which the clumps of unpruned tea already described consist. The reason of the smallness and non-activity of the leaves upon these brush-like masses is simply that they have increased in number out of proportion to their means of nourishment. The stem, through the sap-wood layer of which their nourishment is transmitted, has not increased proportionally with the number of the leaves which have been forced into existence by the operation of plucking; and it is a physical impossibility that through the layer of sap-wood in the stem, there *can* be transmitted enough sap to support many young leaves, in addition to old ones with which its top is crowned. Were such a stem left to itself, and all plucking suspended for a time, it is probable that in some cases an equilibrium would be established between the leaves and sap-wood, and that the latter would again become extensive enough for the transmission of sap

Margin notes: Plucking a method of pruning. — Formation of shoots. — Number of leaves. — Low vitality of flush-bearing twigs. — Weakened stem. — Bushes recover if not plucked.

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sufficient to support a natural succession of young leaves, or, in other words, to 'yield flushes.' But the process of recovery would involve time, which to the tea planter means money. A quicker way therefore of obtaining leaf must be tried, and this is found in pruning off the profitless wiry spray with which the stem is crowned, so that the sap transmitted upwards may cease to be dissipated away in the support of leaves which can never be made into tea, but which, as long as they remain on the plant, must have their needful supply of sap ; and further that the sap may be directed into the new shoots which the plant may be expected to throw out after pruning."

THEORY of PRUNING.

Dissipation of sap.

"It is thus that pruning becomes the necessary sequence of plucking, if healthy young leaves fit for tea-making are sought to be continuously produced. The end in view should never be lost sight of when using the knife, for the mere meaningless mutilation of a plant by its application is quite as likely to be hurtful as not."

Pruning may be hurtful.

5. In summary, therefore, it may be said that pruning is a means of reducing the number of stalks on the bushes to the nourishing capacity of the remaining branches, and to ensure that the particular stalks remaining are the most capable of giving the best and most vigorous shoots the following season. This being so there are certain botanical principles which should be kept in mind in any discussion of the subject:—

Summary.

Botanical principle.

(1) In any given bush the size and vigour of shoots is, within certain limits, inversely proportional to their amount. That is to say, with a given plant the fewer shoots allowed to grow the larger each one will be, and the more strength will there be in it.

Fewer shoots more vigour.

(2) The nearer a shoot approaches the vertical the more vigorous it will be.

Vertical shoot more vigorous.

(3) The more wood left of the last year's growth, the less will be the vigour of the new shoots which arise from it. To leave more wood means that a larger number of eyes from which new branches or shoots may arise exist ; and *vice versâ*. If, therefore, only a short length of wood is left all the energies of the bush have to be expended on a small number of shoots, and these shoots grow with more than ordinary vigour.

Less wood more vigour.

6. It seems evident therefore that in old tea at any rate it is hopeless to expect that a plot can be uniformly treated throughout, and the sooner it is recognised that the pruning should be bush by bush and not plot by plot, the better will it be for the industry at large.

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III.—Treatment of the Young Plant.

TREATMENT of YOUNG PLANT.

Objects in pruning young plant.

7. In dealing with a fresh plant grown from seed, whether in a nursery or from seed at stake, the primary object in all pruning is recognised to be the production of a bush of the shape desired without reference to any immediate leaf production. Not only, however, should the shape produced be of primary importance, but also the permanency of that shape. Thus, it might be possible to produce a bush of splendid bearing shape for four or five years, but if, at the end of that time, it was necessary to cut so low as to spoil that shape, and cause the necessity of making a new bush, such a method would distinctly be inadvisable. And thus a second purpose becomes to produce a bush which will not need heavy or collar-pruning for many years. Thirdly, the necessity of getting the bushes to shade the soil at the earliest possible opportunity should, especially in the hotter and more droughty districts, be constantly kept in view. And lastly, so far as is consistent with the former points, it should and will, of course, be the object of the planter to bring the bush into full bearing at the earliest possible date.

Older opinions.

8. ***Opinions of Authors on Shape of Tea Bush.***—In the earlier days of tea planting the object in view in pruning a young plant was to obtain as long and straight a stem as possible. This was achieved by delaying the pruning for several years after planting, and in some cases by stripping off the branches which showed a tendency to form on the then much-desired single stem. Mr. Shipp, (1865) for instance, says : "Strip off to eight inches above ground, by breaking or cutting them, all the small lower branches." Mr. W. C. Muller says : "Let there be fully ten inches between the surface of the earth and your lowest branches." Mr. J. F. W. Watson proposes that the seedlings should be left alone for the first two years, then pruned down to three feet, and in the third year two or three inches lower still. He then adds : "A plant thus treated has, to begin with, a stout, strong stem, and the pruning adopted leaves it ample room for side development, and it is only at the sides that real development is possible." A Cachar planter said : "An indigenous plant ought never to be touched, or have its growth checked in any way, till the end of the third year, when it should receive its first pruning by being cut back to a height of thirty-six inches."

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TREATMENT of YOUNG PLANT.

Change of view.

9. These views are now to a large extent ancient history. Few, if any, planters would be in favour of—much less lay stress on—the existence of a thick single stem which then seemed so desirable. And as for pruning young bushes at thirty-six inches, it may be said that this is no longer heard of, and has rightly been abandoned almost everywhere. These older methods were based on an idea as to the essential importance of a primary taproot for a tea bush. But while we believe that the presence of deep and extensive roots is essential for the production of a good plant, it may fairly well be asked—"Is the formation of a long, straight tap root so very indispensable to future success?" The roots of a plant are intended to serve a three-fold purpose—(*a*) to procure plant food; (*b*) to fix the plant; and (*c*) to procure water. The plant food is almost entirely furnished by the small fine rootlets constantly growing from every portion of the root, but principally in or just below the few inches nearest the surface of the ground, and a taproot has little or nothing to do with this power of absorbing the fertilising materials from the land. The objects to be served by a taproot—the fixing of the plant, and the supply of water—can, it seems, therefore, be equally served by several deep lateral roots, provided these go to the greatest depth available.*

Importance of roots.

Value of of tap root.

10. A taproot, proceeding directly downward as a continuation of the stem, may be therefore considered, provided deep laterals are present, as non-essential, and hence the *raison d'être* of the high original pruning to 36 inches disappears, as well as that of the late age—three years—at which the authors cited above consider that the first pruning should be carried out. For if a taproot be unnecessary, can it be said that a seedling three years old and 6 feet high has gained any advantage in the direction of the planter's ulterior object (the production of leaf) by being allowed to attain such an extraordinary growth? It has undoubtedly been allowed to run up in precisely the way it would do if growing in its wild habitat, with a tall delicate stem with a few erect or more or less ascending lateral branches. But when the check is given by the pruner's knife, it is now commanded to make up in lateral growth what it has lost in the vain, though natural, effort to form a

Advantage of pruning low.

* A great number of the most experienced planters, it is only fair to say, still believe in the advantages of a deep straight tap root to the bushes.

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vertical stem. By being allowed to grow up to a long stalk it has exhausted energy in this direction which might have been employed in making lateral growth, for, afterward, the whole, or nearly the whole of the straight stem is taken away. The tall tea seedling practically contains neither branch nor bud that is not possessed by its less vigorous sapling of corresponding age. The whole question is, therefore, one of the age at which it is most advantageous to give the first check to the natural tendencies of the plant.

11. As a result of these arguments it will readily be seen that we are inclined to believe that the planters will best be served by pruning a fresh tea seedling as low as possible, as early as possible in its life.

12. ***Height of First Pruning.***—With regard to the former point we have recently had the opportunity of comparing, in a young garden in Sylhet, where other conditions were absolutely equal, the effect of making the original cut at 2 feet 3 inches from the ground, or at 15 inches. The latter was in every way preferable: the bushes of the same age were more vigorous, there was less hard grey coloured wood in them, and there was prospect of a far greater return in the near future. Though we say "Let the first pruning be as low as possible," definite rules as to the exact height cannot be laid down. The best part for cutting will vary with many factors, and especially with the *jat* of bush. Thus the "Assam indigenous" tends to form a straight single stem,—the Manipuri type, on the other hand, shows a much greater tendency to branch almost from the level of the ground—and hence it will be necessary to cut the former much lower than the latter to produce the best type of bush. In confirmation of this it may be said that the best practice in the Assam Valley is now to cut not higher than 6 inches from the ground, and in many cases at 4 inches: in the Surma Valley, on the other hand, where Manipuri plant is almost universal—and rightly so—it is the custom to cut at 12 to 15 inches from the surface of the soil, with the result that a bush is more quickly formed than would be the case with lower cutting. As hybrid plant is somewhat like Manipuri in respect of tendency to form low branches, it may well be treated similarly.

Difference in method due to *Jat.*

Difference in practice in Assam and Cachar.

13. The question is not, however, so much as to the exact height at which the pruning should take place, but the recognition of the fact that if a bush shows a tendency—even after pruning—to again

No single stems allowed.

TREATMENT of YOUNG PLANT.

form a single stem, it must be cut again, or removed, or not planted, as the case may be. A plant with such a tendency in a plot—unchecked—will be a source of worry and trouble in the future.

Time of first pruning.

14. ***Time of first pruning.***—Not only should the first pruning, however, be as low as possible, it should also be as early as possible. In our opinion it should, under no circumstance, except perhaps in filling in vacancies, be deferred beyond two years from the date of germination. It would even be better if made at an earlier date so as to ensure that the stunted stem thereby produced may contain in, say, 9 inches, all the buds (possible originators of branches) of a much greater elongation of the three years' seedling.*

Nursery pruning.

Pruning after planting out.

15. There seem two ways of carrying this out. One way—prune the seedlings in the nursery when six months old, and plant several months later when they have recovered from the shock—no plants being put out which do not show the production of lateral shoots. Or the plants may be put out as six months' seedlings at the commencement of the rains and then pruned late during the following cold weather, or put out at one year old, and pruned the following cold weather. Between these two systems there is, on principle, perhaps little to choose. The former gives a greater power of selection of suitable plants when they are actually planted out—a selection which is very necessary even with the best nurseries and the best seed. In the latter, owing to the plants being further apart after planting, there is a greater natural tendency to branch from the base at once.

Exception in Darjeeling.

16. There is perhaps one notable exception to the applicability of these principles. In a less favourable climate for tea, such as that of Darjeeling or other hill districts, it seems necessary to leave the plants considerably longer before they are pruned, simply because in order to reach the same state of development they require under these conditions a considerably longer time. Therefore, whereas we have said that the original pruning in the plains districts should be carried out when the plant is not more than two years old, this time should be extended to at least two and-a-half to three years in the hill districts.

* The system carried out in the Jorehâut Company has been kindly described for us by Mr. Showers, the Superintendent, as follows:—"My practice has been to prune the plant to a 2 feet measure a year after planting (in new land), and at 4 inches to 9 inches the second year.—4 inches for straight stems and 8 or 9 inches for those with two or more. I do this because I think that heavy pruning should wait till the plant has a good hold on the soil."

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Treatment after first pruning.

17. ***Treatment after the First Pruning.***—When the plants are pruned and planted, however, watchfulness is by no means at an end. In some types of plant the tendency even then to heal up the old cut and form a single stem bush is very great. In a case in mind this tendency was effective in ten per cent. of the plants. Under such circumstances the stem should be again headed down, and several—not less than three—lateral shoots will probably be obtained. If not, it must be replaced by another seedling. It may be said that all this involves far more care than can be given to a plot of young tea, but when it is remembered that the bushes when produced represent the capital value of the garden in large measure, it is hardly too much to believe that no amount of care can really be too great at this stage of the growth. Whatever else is neglected the pruning and growth of young seedling tea should receive the very best attention and care possible—and this not only as regards the plot as a whole, but even as regards every individual plant.

Best attention required.

Second pruning.

18. ***Second pruning.***—At this stage comes the most difficult point in the pruning of a young tea bush. We will suppose a plant obtained with three, four or five branches rising from various points in the stem from two to, say, six inches from the ground. When shall the next pruning take place? Is it advisable to leave much wood, or to cut down low on the laterals thus obtained?

Amount of wood to be left.

19. In deciding what method to adopt it is, we think, important to consider that it is at this stage that the framework of the bush for many years to come should be formed, as, unless the original prunings have been bad, collar-pruning should be out of the question for a long time. The question of immediate yield should not enter at all into consideration. This being the case, the natural conclusion would seem to be that at this stage, and at this stage only, should a considerable amount of wood be left in the bush, and this for the following reasons :—

1. It is necessary to provide somewhere for the exhaustion of the younger bearing wood, and to allow for heavy pruning. It should be possible to carry out this heavy pruning without destroying the form of the bush, and still obtain good straight non-knotted stems. If at the present stage the stems be left short, it will only be possible to cut back into them once or twice, whereas if more space be left

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Reasons given.

they can be utilised for heavy cutting several times before it is necessary to go down to the ground.

2. It has been laid down as an axiom that the shorter the wood left in pruning, the greater the vigour of the shoot which arises from it. It is hence advisable (see below) to leave as little wood as possible at each successive high pruning of the bush, and so at no future time will there be the chance to leave wood for a framework of the bush. At the present stage, however, the vigour of the young plant is sufficiently great (or ought to be if the land is at all suitable for tea) to render each of these main branches capable of nourishing sufficiently and vigorously the head of leaf which will form from it.

20. From every point of view therefore it seems wise to leave a considerable amount of wood at this stage; but how much? This is most difficult to answer from a theoretical point of view, but it seems that if one allows two inches to be taken off at each successive heavy pruning, it would be wise to allow for four such heavy prunings, and this leaves ten to twelve inches of new wood, or prune at fourteen to eighteen inches from the ground. There is, however, nothing absolute in these figures, and local conditions will have a great deal to do in deciding the exact point at which this critical second pruning should be made.

Leaving bush unpruned after second pruning.

One more question arises in connection with the stage now under consideration. Is it advisable to leave the bush unpruned for a year after the first cutting,* say, at six inches from the ground, before that at fourteen to eighteen inches, in order that the plant may get a thorough hold on the soil, and develop for so long in a natural and

* On this point Mr. Showers remarks :—" I am inclined to favour pruning, so that the pruning cut may be made directly over an eye, and that the cut may heal over in a better or more complete way than it would in more mature wood."

Mr. Lennox of Luskerpore, Sylhet, remarks on the same point :—" I agree with you if the first cutting has been made at six inches from the soil. Cutting at 12 to 15 inches is more usual in Sylhet and Cachar, *i.e.*, six months seedlings, two years after planting : to leave these the next year unpruned is a loss and a fallacy. I have carefully noted the results of pruning and leaving unpruned and I find that the bushes that were pruned were much the superiors in appearance and in yielding capabilities, and, on the whole, better formed bushes." " I always leave unpruned, in my second year's pruning, all plants that are weakly and have insufficient growth, and pluck none of these bushes till August or September, and then only if I consider they have sufficiently recovered."

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ordinary fashion? We think it is. By this means the wood from the first to the second cutting becomes more mature and more capable of giving rise to new vigorous shoots.

21. Another method which avoids an original very low pruning altogether has recently been adopted by several Assam planters of experience. The bush is made to throw out lateral shoots merely by planting out at six months old in the garden,—the openness of the surroundings if the land is well hoed making the tendency to form lateral shoots predominant, and these arise almost from the base of the stem. The first pruning is therefore at fourteen to eighteen inches, but a bush is formed before this pruning is carried out. It is claimed by this means that at no time does the bush receive such a shock as the original four to six inch prune must be, and yet a plant of the desired shape and character is produced. There seems no theoretical reason why this should not be the case, but, personally, we have not seen enough of the method to be able to express a confident opinion, and can, hence, not at present recommend it.

22. Thus we have three alternative schemes for the treatment of the young bush, as follows, though it must be recognised that each of them may demand modification according to district, climate, and soil.

I. *a*. Prune in the nursery at, say, a year old.
- *b*. Transplant at eighteen months old (before or in the rains), or at two years old in the cold weather.
- *c*. Allow the plant to grow without further cutting till three years from seed.
- *d*. Prune at three years from seed 14 to 18 inches from the ground.

II. *a*. Transplant into the garden at six months or one year old.
- *b*. Prune at one year from seed if planted at six months, or at two years if planted at one year old.
- *c*. Allow the plant as before to grow for a season without pruning.
- *d*. Prune at three years from seed 14 to 18 inches from the ground.

In this scheme it may perhaps be most advisable to leave pruning till two years from seed, thus giving a better chance for the plant to get a hold on the soil.

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In any case if an Assam indigenous plant is being dealt with, the original pruning should be 4 to 6 inches from the ground; if a 'Manipuri' it may be considerably higher.

III. Is the method set out in paragraph 151* of which we havé not seen enough to either recommend or condemn.

IV.—Pruning of Mature Bushes.

PRUNING of MATURE BUSHES.

Annual pruning universal in India.

23. Throughout the tea districts of Northern India it may be said that an annual pruning is practically universal. The same is by no means true of Ceylon or South India, as there, we understand, it is the regular custom in the gardens at high levels to leave the tea two years without pruning, and even in some cases three and-a-half years have been allowed to elapse between successive applications of the knife. It has been and is occasionally the custom in North India, however, to leave the weak bushes on a plot unpruned for a year with the idea that by this means they would be induced to form better wood which would, in the future, produce more vigorous shoots. Such a proceeding has some very obvious advantages. There can, for instance, be no damage from over-plucking during the unpruned years, the bush has to make no new wood and is hence partially resting, and an early yield is obtained. On the other hand, such bushes always feel drought more, should it occur, than if they had been pruned; they often get red spider badly, and act as a nursery for mosquito blight; and the leaf becomes smaller and more difficult to pluck. Altogether we are inclined to think that the practice of leaving the weak, poor, bushes in a plot unpruned for a year is distinctly a good one, under ordinary circumstances, provided always that a dose of manure—preferably cattle manure—is given to the bushes so left. Without manure we doubt very much the advisability of so leaving the bushes, as then the disadvantages seem to more than counterbalance the benefit which might otherwise be derived. But, given manure, the method of leaving unpruned seems the only way to ensure that the weakly bushes shall not be plucked like their vigorous neighbours, and

Leaving bushes unpruned.

Manure required.

* The system used in the Joreháut Company (for which we are indebted to Mr. Showers) is, 1. Transplant at one year old; 2. Prune at two years old to 24 inches; 3. Prune at three years old to 4-9 inches. Mr. Showers further remarks:—"The II. plan (see above) is the best of the three plans, but it is not always convenient to transplant at that age (6 months). In the system of transplanting at one year old, there is a better chance of selecting good healthy plants."

PRUNING of MATURE BUSHES.

to allow them a partial rest from the strain of not only making leaf but also making new wood. Such leaving will, as a rule, involve heavy pruning at a later date—generally the next year—and it would hence be wise that the weakly bushes should be left unpruned the year preceding that in which it is intended to heavy prune the plot.

Leaving blocks unpruned.

24. This applies to weakly bushes, but there has been a general tendency to adopt a system of leaving whole blocks unpruned occasionally for a season. The result is said to be that a large yield is obtained from the unpruned sections in the early part of the season, and that the previous year's growth has time to mature and will become a better basis for future yield. It has even been suggested to us by a planter in Cachar that half a garden should each year be left unpruned, and so an earlier crop be obtained, and the rushes of leaf—beyond the power of the estate to cope with, so common in August and September—be largely eliminated. Without going so far as this there seem conditions under which it is distinctly advisable to leave blocks unpruned. Among these are the following :—

Advantages.

1. In year following heavy pruning.

1. In the year following heavy pruning, on all except the richest lands, it appears very much to be recommended that the bushes should be left without any treatment with the knife. Of this, however, we will speak when considering heavy pruning.

2. When in hard unyielding condition.

2. When, owing to exhaustion of the soil, previous bad pruning, or too hard plucking, the bushes are in a hard unyielding condition. Under these circumstances it seems perhaps the wisest plan, in the ultimate interest of the garden, to manure heavily, leave unpruned a year, and heavy prune the following season. By this means a certain amount of vigour is returned to the bush by the rest and the manure, and when cut hard it will probably respond far more quickly and strongly than it would otherwise have done.

3. For the sake of quality.

3. Whenever, in the absence of serious danger, whether of a spring drought, or a serious dose of red spider, or other spring blight, and in the presence of a large labour force, there is great advantage in making high quality spring teas. Mr. Bamber strongly holds the close connection between the quality of tea and distance from pruning of the wood from which it is grown, and if this be so, there is strong reason

PRUNING of MATURE BUSHES.

why some part of the garden should not be left unpruned each year, provided, of course, there is a sufficiently large labour force to deal with the leaf, which will be difficult to pluck. The decrease in the size of leaf as the bushes get further from pruning rapidly puts a limit to the possible length of time they can be left, and, in any case, only a part of the garden can by any possibility be so dealt with each season.

Season of annual pruning.

25. ***Season of Annual Prunings.***—There may be said to be a consensus of opinion in favour of the annual pruning being delayed as long as the strength of the labour staff will admit. Some few writers have said, however, that pruning should be commenced immediately after the sap has ceased to ascend. This we venture to affirm is a mistake. What object could there be in needlessly exposing the cut surfaces of the branches and twigs to the drying influences of the atmosphere? Absolutely no effort will be made by the plant to cover the wounds till the sap begins in spring to carry up the food-supplies. This early ascending sap, however, has to be assimilated by the old leaves on the bush and be sent by these to the cut surfaces. This fact shows how very ill-advised the system is to direct the pruners to pluck off all the old leaves from the bushes. This should on no account be done, except in special cases, since assimilation will thereby have to be accomplished by the bark of the few young twigs still remaining on the bush, and the bursting forth of the new shoots will accordingly be greatly retarded. The special cases referred to are when the older leaves carry blight of various kinds, such as grey blight, brown blight, red rust, etc., when it may be advisable to remove these blighted leaves, but no others, at pruning, otherwise, if it be desired to remove the old leaves, this had best be done after the new shoots have appeared, certainly never before, and better never at all. It has been said that the occasional removal of all the leaves at pruning (the so-called "stick-pruning") causes the bush to manifest greater energy the following season, and it has even been maintained that such stick-pruning was a substitute for collar-pruning in its effect on the bush. This is probably the case in some climates and soils, though it is difficult to understand, but it is a risky thing to do, and in any case must not only be restricted to Upper Assam, but, even there, be a very occasional operation in each block.

Early pruning condemned.

Stick pruning.

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PRUNING of MATURE BUSHES.

Tendency to become earlier.

26. In spite of the fact that on principle late pruning is recognised as correct, there is a general tendency for the pruning to become earlier rather than later as years go by. This tendency is to be discouraged for several reasons in addition to that above given, chief among which is the fact that by early pruning early growth is induced, which, supposing a drought follows, is of no value, and the bush, say in May, has to start to throw out an entirely new set of shoots, different from those which originally grew. Now, seeing that droughts, by very general testimony, seem to be becoming increasingly common in many districts, for this reason, if for no other, the pruning should be delayed so long as is feasible. A second reason in favour of late pruning is that red spider is invariably more severe on the blocks which first received the knife. A very prominent planter recently said to one of us that in his opinion the best cure for red spider was late pruning, and, partly at any rate, we are inclined to agree with him. Not only red spider but also other blights are made worse, apparently, by early pruning—mosquito blight, contrary to the idea generally received a few years ago, being one of them. There seems a very great body of evidence now in existence pointing to late pruning as distinctly indicated in districts liable to this most serious pest of tea.

Late pruning recommended.

Position and Angle of section.

27. ***Position and Angle of Section.***—The time of pruning having been decided upon, the most important consideration is the position and angle of the section cut. If the knife be inserted below the base of the bud and a long slanting section be made, the bud will be starved and thus produce a sickly shoot. If the section be made at a point, say from half an inch to two inches above the bud, the protruding portion will be starved and die accordingly. This is the condition known to the gardener as a "*Snag*," the evil effect of which can be found in almost every garden. When in spring the sap ascends to the shoots an accumulation takes place at a point near the topmost bud. This swells in consequence, the bud bursts into foliage, the leaves commence the process of assimilation, and had the section been properly made, the elaborated sap would have, in a comparatively short space of time, caused the bark to heal over the section and extend into the new shoot until the existence of a wound had practically disappeared. This result is most desirable, for fully matured or dead wood obstructs the circulation of the sap and retards growth. Instead of healing over, when a snag has been

Snags.

Their effects.

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PRUNING of MATURE BUSHES.

left, the effort made causes the swelling to grow larger and larger around the base of the projecting, useless and dead apex of the old twig. The snag when it dies becomes attacked by white ants and other vermin. It is thus decomposed so that, instead of a united bark covering the wound made in pruning, a hole is formed that fills with water and sets up decay that extends far below the point

FIG. 1.—EXAMPLE OF RESULT OF BAD PRUNING FOR SEVERAL YEARS.
(From a Photo. in Sylhet by H. H. Mann.)

of origin of the new shoot, upon which the year's (or it may be several years') flushing depends. This is no imaginary picture, but is found everywhere—worse, no doubt, in some places than in others, but present in all. Figure 1 from a photograph taken in Sylhet of a typically badly pruned branch shows several snags and their effect.

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CAMELLIA Thea. **Principles of Tea**

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28. The formation of a snag may not be of very serious consequence in the year immediately preceding heavy pruning, but it is easy to find stems on which snags have been formed year after year, for ten or fifteen years, until gnarled rotten swellings, corresponding to each year's prunings, may be said to have slowly starved the plant. This fact hardly needs further illustration. The sap ascends freely within the sap-wood of the well-formed stem till it comes to a great swelling that corresponds to the position of the first pruning. Wandering round this it ultimately finds an escape, let it be supposed, to the right along a branch some 6 or 8 inches long. At the extremity of this it is a second time obstructed by swelling, which is due to a snag. We may next suppose that the current is thereby deflected to the left. It finds an outlet, however, along a more or less sickly twig. Thus, this way and that, the ascending sap is obstructed on every hand. Is it to be wondered at, therefore, that against such difficulties an insufficient supply is drawn to the growing parts of the plant? Instead of being vigorous, the flushing in each succeeding season gives distinct indications of declining activity.

Sap calculation stopped by bad pruning.

29. But the full significance of retarded circulation of sap is only obtained by studying the course of the downward current. So far as is known, no portion of the ascending fluid can be utilized till it reaches the leaves to be there assimilated. While the process of assimilation is taking place, the pluckers visit the bush and the majority of the young shoots and leaves are removed. What remains of the assimilated fluid now begins to descend, but, as it has to permeate backwards and forwards through all the woody portions, the knots of dead wood formed at the snags become, not deflecting influences, but positive obstructions. It is, therefore, only natural that the lower and older portions of the stem are literally starved and often manifest immense open scars corresponding to old snags. Such bushes might, in fact, be spoken of as living at the top and rotten at the bottom to an extent beyond what words can portray. No person who has not seen a really bad tea garden can form any conception of the miserable conditions under which the tea plant will still continue to live and even give dividends to its owners. For such a state of affairs, if the obstructions are of recent growth, it may be sufficient to cut below these knots, but where the obstructions are of old standing,

Effect on downward current of sap.

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Remedy for bad pruning.

collar-pruning is the only method of dealing with bushes of this sort. While saying this, however, it should be remembered that we regard the fact of the bushes being in such a condition not as a necessity in old tea, but as being the result of bad pruning, and hencé of bad management, in the past, and that the necessity for collar-pruning from this cause is itself a condemnation of the previous method of dealing with the bushes.

Correct pruning.

30. To avoid such a result the annual pruning should, for every individual twig, be conducted so that the cut leaves practically no wood above the bud from which the new shoot is to arise, and so that the cut makes an angle of about 45 degrees with the stem of the bush.

Cut out Snags as soon as possible.

31. It is often impossible to know where the bud will appear in a tea bush, and hence it is often difficult, if not impossible, to arrange that the cutting should be at the place to avoid a *snag* formation. It is only therefore the more important that the following year the snags formed in the previous season should be removed when the regular pruning is carried out.

Length of wood to be left in pruning.

32. ***Amount of wood to be left in pruning.***—The next point to discuss is the question how much wood, of that formed in the previous year, should be left in ordinary light pruning. It has been laid down as an axiom in the early part of this chapter that the vigour of the shoots which result after pruning is *increased* by shortening the length of wood from which they grow. Seeing that in tea pruning the object is to produce maximum vigour in the bearing shoots, it would seem to naturally follow that the less wood left, provided it contains a bud, actual or dormant, the greater would be the advantage. This would seem to have been found to be the case in practice. A few years ago four inches appears to have been the amount usually left on top of the previous pruning, but this has been reduced, and in our opinion rightly reduced, with corresponding increase in the vigour of the flushing growth. This is not the place to say exactly how much should remain of the previous wood ; this would depend on the district, the luxuriance of the plant, the probability of the existence of dormant buds in the shoots, and other influences, but we cannot see why more than two inches ("three fingers") is of any advantage as a rule.

33. And here we come to one of the most disputed points in the whole of tea pruning, and one in which we have formed an

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opinion contrary to the general practice. Basing our statements primarily on theoretical grounds, we fully feel that there are perhaps reasons in practice which render it advisable to depart from the bare principle, but nevertheless we have seen most successful pruning for many years in succession carried out in accordance with the principle which follows, and hence we do not depend entirely on theoretical teaching. A very usual attempt in light pruning a tea garden is to cut the top of the bush flat, or, in other words, it is what is technically known as "table-pruning." This involves, as will at once be seen, the cutting of the central shoots in the bush at a much shorter distance from the source than those at the side. Now the result of this, according to the principles already laid down, will be that the shoots at the centre of the bush will be much more vigorous than those at the side, and this difference will increase with every successive light pruning. The result ultimately obtained after several years of upward light pruning is a small area of vigorously flushing shoots in the centre of the bush, gradually becoming less and less vigorous towards the circumference, the extreme outside producing practically nothing but a few *banjhi* twigs. That this is the case not merely in theory but also in practice is common knowledge on almost every tea garden, and the remedy is usually considered to be heavy cutting. And when this condition has been reached truly there is no other remedy. But what we would point out is that such a condition is a necessary result of a bad system of pruning, and can in large measure be avoided—and hence heavy pruning avoided—by a better system of conducting the annual light pruning.

Table-pruning condemned.

Unnecessary heavy pruning.

34. According to the principles we have laid down, the luxuriance of the new shoot largely depends, other things being equal, on the length of wood (left by the previous cutting) from which the new growth arises, and that the shorter this length is the more luxuriant will be the growth. Now, in the system of table-pruning, so common among those who make a fetish of a broad bush, it will easily be seen that the shoots in the centre are cut the shortest, and those on the edge the longest, and that hence the maximum of luxuriance will be in the centre, and this will decrease as one proceeds outward. This effect multiplies itself with every additional light pruning, and it is easily seen that the form of bush with a yielding centre surrounded by a ring of *banjhi* twigs is rapidly

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produced. Another cause adds to the evil effect. Table-pruning involves the retention of those nearly horizontal, more or less weakly shoots, which spring from the side of the bush and increase its area, but which when pruned are pruned long, and on account, also, of their method of growth are never luxuriant.

Broad bushes.

35. It follows, therefore, that we do not agree with that simple form of pruning which consists in cutting the garden level, and dignifying the process by the name of "table-pruning." The object in view should be to get as great a surface of plant as possible, *provided the surface is a yielding surface.* To extend the area of the top of a bush for the sake of producing a surface of *banjhi* twigs seems to us by no means rational. It has often been said that with the labour available the only system possible is that just condemned; but we have seen some gardens in which a different method has been carried out with great success, though the labour was of precisely the same kind, and hence it hardly seems that the argument can be really a valid one.

Proper methods of pruning.

36. But how then should the shoots be cut in light pruning?—On principle it would seem that as the object in view is to produce an equally vigorous area all over the bush, the new wood on each shoot should be cut to approximately the same length, and that hence the pruning coolies might almost be supplied with a measure, say "two fingers," to leave on every shoot on the bush. We are aware that such pruning would not look nice, and not nearly so elegant as a fine piece of table-pruning, but we do not think it is held by any one that pruning is carried out for appearance' sake, and if a higher yield of equal quality tea is obtained, it is full justification for an ugly looking garden at the end of the pruning season. This might be looked upon as a theoretical position, but gardens have been brought to our notice this year in which what is more or less this system has for several years been carried out, and the result has been all that one would have expected.

Vertica shoots most vigorous.

37. There is another point in this connection equally important with that just made. The most vigorous shoots it has been said are those which approach most nearly to the vertical position. Would it not therefore be well, on the outside of the bush where the bulk of the young shoots are horizontal or nearly so, to head these back, and so encourage the formation of vertical shoots at this part

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Cutting the sides.

of the plant even at the cost of a certain amount of bush surface? In other words is "cutting the sides" of the bushes advisable or no? On principle we say emphatically that such a process is not only advisable but necessary if the maximum result is to be obtained per square foot of bush area.

Random cutting of the sides condemned.

But here again there is all the difference between cutting the sides for the purpose of inducing vertical growth, and cutting haphazard everything which the knife touches, and of course the difficulty of getting good work done with an uninstructed labour force comes very prominently into the consideration of the subject, and it is evident that such a method demands very considerable supervision. But that it can be carried out, with fairly satisfactory results, we have been convinced by our own eyes, and if it can be so done the careful and scientific cutting of the sides of the bushes, to induce vertical growth, becomes a most important part of the pruning.

Thinning out the bushes.

38. ***Thinning out the bushes.***—It is evident that the vigour of the shoots which a single bush can support will in ordinary cases be in inverse proportion to the number present in the bush. Thus, for instance, if a bush carries, say, a hundred small shoots, none of these will be so vigorous as those on the same bush carrying twenty shoots. Further, if, say, sixty per cent. of the larger number of shoots are small and twiggy and never likely to yield any but *banjhi* leaf, it is evident that their presence in the bush will merely take away from the strength of the remaining growth without themselves yielding any return. Now at the end of every season there are always found a large number of such small twiggy shoots in every bush, which from their position and formation can never become of service for leaf production, and the question has been as to whether they should be removed during the annual pruning.

On the face of it, being no use for leaf production, these twigs should always be cut out, and cut out right at the bottom, leaving no snag behind. We have been informed that the best way of removing them is to pull them clear away, and not cut at all.* Various

* On this point Mr. Rose of Doloo, however, says: "During all my experience I have found that small thready twigs in a bush should be cut out, not torn off. This last gives an opportunity to white ants to start, and during the wet season the scar made may grow into an open sore. The twigs left only sap the vigour of the bush, and keep out light and air during the season and lead to an early close."

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objections have been taken to their being removed. It has been said, for instance, that the leaves on these twigs form the lungs of the bush during the time there is no new growth. This objection will not, however, hold water for a moment. The leaves which are left on the bush in any case, whether thinning out is done or not, are quite sufficient lungs during the dormant season of the plant. The argument would be valid against the unnecessary removal of leaves, but is certainly not so against the pruning off of useless, thieving twigs. It is said again that these twigs, with their foliage, protect the pruned bush from the sun, during the dry hot weather, and in hot districts, and we have here an important argument in favour of leaving the twigs in question on the bush. But, even here, we have the balancing of two evils—the evil of hot sun on pruned wood, and the evil of many *banjhi* twigs in the bushes. Though it needs a carefully conducted experiment to render the matter quite certain, yet we should strongly incline, even here, to thin out the bushes of the useless, non-bearing, small, twiggy, *banjhi* shoots, and just leave as many branches in the bush as the plant is able abundantly to nourish.

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Thin shoots do not form lungs of the bush.

39. There may be cases to which these arguments do not quite apply, and where, as in a well planted bheel garden, the bushes seem capable of producing luxuriant rank growth from every shoot left in the bush ; but these are possible exceptions, and there seems strong evidence, from observations made during the present season, of the validity under practically all conditions of the arguments just set out.

Bheels an exception.

40. The annual pruning then, in summary, should remove the following parts of the bush :—

Parts to be removed in pruning.

1. All dead branches.
2. All gnarled twigs and crows-foot clumps of imperfectly formed shoots—last year's "*banjhi*" flushings.
3. All snags which are seen to have little chance of healing over. The longer the removal is delayed the worse for the bush.
4. All "trailing" branches at the outside of the bush.
5. All the last year's horizontal shoots at the outside of the bushes should be headed back to induce them to throw out vertical shoots.
6. All small twiggy shoots throughout the bush which will never give strong, healthy yielding material for the next year.

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New wood to be left.

These should be cut right back to the stem from which they arise, or pulled out.

In addition, the amount of new wood should be as little as possible consistent with this containing one bud—dormant or otherwise, and if possible the same length should be left on each pruned shoot throughout the bush.

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V.—Heavy Pruning.

41. ***Reason for Heavy Pruning.***—Though more rational methods of annual light pruning will make heavy pruning necessary less often than it would be otherwise and has been in the past, yet just as pruning at all is necessary to remove the refuse mass of twigs which plucking, say, twenty to thirty times in the season, leaves on the bush, so heavy pruning is necessary to remove the refuse of several years of light pruning. It need hardly be repeated that the idea should be kept clearly in mind that successful flushing involves the starvation of the stem, and more especially of the stem immediately below the plucking point which cannot be fed by the large mature leaves on the higher branches. Hence it becomes less and less capable, as the bush is plucked year after year, of giving vigorous shoots again, and heavy pruning becomes the necessary sequel to light pruning.

Heavy pruning necessary.

42. But this should not blind one to the fact that it is an evil, though a necessary evil, and that, being so, it should never be undertaken without adequate cause, and certainly never for appearance' sake. Though it would hardly be deemed likely, yet this is often the cause which determines the heavy pruning of a section. No record of yield per plot is kept, no knowledge is in the hand of the manager as to whether the yield of the plot is stationary or declining, and it is casually decided that the plot is in need of heavy pruning, and it is pruned accordingly. We maintain that such a process is irrational in the highest degree. Heavy pruning should be determined by yield, and if records are kept they will quickly show the necessity or otherwise of the process.

Not done at random.

43. But though sooner or later essential, there are several causes which make the heavy pruning of a block necessary sooner than it would otherwise be. Of these the first and perhaps most important is exhaustion of the soil. Given a rich soil affording

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abundance of nourishment to the bush, the starvation of the stem will be much retarded, and hence the heavy pruning; but given an old, possibly a washed, exhausted soil, and starvation immediately occurs, the wood acquires the greyish appearance characteristic of non-bearing wood, lichens grow on the stem right to the tip, and the bush is said to be "hidebound" and needs heavy pruning. We remember well a case in Upper Assam where a steep slope was planted with identically the same bushes at the same time. At the time of our visit the top of the slope was as we have described it and badly in need of heavy pruning, the bottom had magnificent bushes; and the only method of accounting for it was that the surface soil had washed from the top to the bottom of the slope, the upper bushes had been starved, especially the tips of the branches where the flushes should occur, and they would have to be removed before much improvement could be expected, while those at the bottom were still vigorous and well fed. Another example illustrating the same thing was found in a Sylhet bheel garden. No heavy pruning had taken place for twenty years and none was needed. The soil was rank enough to sustain the flushes, and the starvation of the stems, even near the tips, had been only comparatively slight. It may be said, in fact, that there is an inter-relation between the richness of the soil and the need for heavy pruning, and that if the soil be kept good and rich by manuring before the plant begins to show signs of exhaustion, the necessity for heavy pruning will be postponed without loss of yield. This inter-relation of soil and heavy pruning seems to us a most important matter not sufficiently recognised at present by the majority of planters.

Exhaustion of the soil.

Hard plucking early in season.

44. But that starvation of the tips of the stems which renders heavy pruning necessary can be more quickly produced by over-plucking in the early part of the season than by any other means. If a due amount of leaf is left in the first, second, and third flushes, these new leaves, as they mature, feed the stem: if little or none is left, the stem starves. The starved look of bushes plucked hard in May and June (as is so often seen in some gardens) is a proof that in this point practice is in agreement with the theoretical conclusions.

Stimulating effect of heavy pruning.

45. But heavy pruning is not merely a method of removing the refuse non-yielding wood from a bush: it also has an effect in directly stimulating the plant to greater exertions, and this is evi-

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denced, if by nothing else, by the greater development of small, useful feeding rootlets after the heavy cutting of the plant, provided the soil is such as to allow of their formation. This is probably one of the principal reasons in some cases why heavy or especially collar-pruning has been such a great success. The bushes are a mass of useless wood; inadequate feeding of the root energies takes place, and hence little new root growth takes place. The bush is collar-pruned, the whole of the new growth spends its time in feeding the root, and innumerable new and valuable rootlets make their appearance, and the result is a magnificent bush, which, if dealt with properly, gives a better plant probably than has ever been in the place before.

Position of heavy pruning.

46. ***Position for Heavy Pruning.***—Heavy pruning being accepted as a necessity, the question next arises as to how the place in the bush at which it is necessary to carry out such heavy pruning may be ascertained. And here one reaches one of the most difficult questions in the whole business—How far is it necessary to go with the knife? The whole question is so extremely difficult to decide that there is no matter on which planters are more at variance. It is extremely common to hear in one district one man declare that he never believes in taking more off the bush than can be avoided, while another declares in favour of collar-pruning under the same circumstances: and both are successful!

Experiments in progress.

It is evident that information on these points can only be obtained by experiment, and such an experiment or series of experiments was suggested some years ago by one of the authors, and, on the initiative of the Indian Tea Association, are now in progress in several parts of Assam—in Dibrugarh, in Jorhat, in Bishnath, and in Nowgong. The design is to take plots whose history is fairly well known but of which the yield has greatly deteriorated, manure as much as is needed, and prune in different fashions, taking careful note of the result. As these experiments have not yet been in progress for two seasons, it is impossible to give results at present, but in the near future these will be obtained—of a very interesting character we do not doubt.

47. In the meantime although the amount of cutting needed in any case must remain to a large extent a matter of doubt, yet there are some principles which, we think, may be looked upon as

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more or less certain even with our present knowledge of the question.

Framework of bush retained if possible.

In the first place, heavy pruning should not disturb, where this is possible, the shape and framework of the bush, and where it is necessary to cut so low down that this is destroyed, collar-pruning is indicated. The random use of the knife is to be avoided. It takes several years to build up the skeleton of a good bearing bush, and it would seem to stand to reason that this skeleton should not be disturbed except in case of absolute necessity. We should not probably have insisted upon it had not such a huge amount of what might be called random pruning been carried out in the past five years.

No knots left.

Secondly, as few knots as possible should be left below the cutting. If a bush be built up on the lines indicated in the earlier part of this article, there will be practically no knots below those representing the series of light pruning which it is desired to cut out, and "straight wood" will be reached with the least sacrifice of material.

Conf. with paras. 18-22.

Lichen and moss removed.

Thirdly, grey lichenous growths on the bush are a sign that the wood on which they are taking place has ceased vigorously growing, and when they become thick, the inference will be that either the stems must be made more vigorous by manuring or else be cut out. This, however, hardly altogether applies to the Darjeeling and other hill districts where lichen and moss growths are commoner than anywhere else.

Manuring necessary.

Fourthly, a necessary corollary, in nearly every case of heavy pruning is manuring. We, ourselves, prefer that this should be done the year before heavy pruning, but, whether it is done previously or at the same time, it should be an absolute rule in almost every garden that there should be no heavy pruning without manuring of the land. This is only to be expected seeing that exhaustion of the soil is one of the principal reasons why heavy pruning is necessary, and the cause of the failure of much heavy cutting to rejuvenate the bush is, beyond cavil, the absolute impossibility of the roots, new or old, finding sufficient material in the soil to build up the new shoots and branches required. If manuring is not done, heavy pruning is only a means of putting off the evil day when the plot will have to be abandoned entirely owing to exhaustion of the bushes due to previous exhaustion of the land.

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HEAVY PRUNING. Time of heavy pruning.

48. ***Time of Heavy Pruning.***—It seems the usual custom to do the heavy pruning on a tea garden as early in the pruning season as possible. Mr. Bamber defends this in the following words:—"It is generally acknowledged that plants, although apparently dormant through the cold season, are slowly accumulating plant food from the soil, and storing it in their stems and branches; by early pruning, therefore, none of this reserve material is removed from the plant." If the sap circulation is stopped it is difficult to see how this storage could be accomplished, but admitting that there may be some grounds for the opinion, the whole question was a matter for experiment to decide. In Assam, at any rate, opinion, after many trials, seems to have agreed that the heavy pruning should be done before the light pruning on a garden, and not later than January. This is the conclusion in spite of the long exposure of the wood to the sun, and in spite of the likelihood that white ants may attack the dried up cut ends of the stems.*

Treatment after heavy pruning.

49. ***Treatment of the bush after heavy pruning.***—Nothing can be more fatal than hard plucking of a bush after heavy cutting. It prevents the formation of good bearing wood; it causes the maturing of the wood, already formed, too quickly, because it is starved owing to the removal of the leaves which ought to feed it; and it brings about a stunting of the new feeding rootlets which are made to develop by the heavy pruning. In fact, we might say that we should be in favour of the easiest possible treatment after such a process,—no plucking under a very liberal measure, and even no pruning in the following season unless the heavy cutting has only been very moderate in amount. A middle pruned (*bich kalam* or *maj kalam*) bush might perhaps be light pruned again the following season, but below that it would seem far wiser to allow the bush to grow naturally for another year.

Leave unpruned if possible.

We are well aware that this leaving unpruned after heavy pruning means the sacrifice of yield for the time being, but, though it may be impossible to prevent it, we are convinced that the sacrifice of everything, including bushes, to immediate yield has been one of the greatest curses of the tea industry in recent years. A place increases in crop marvellously for a season or two, and every one

* "In all districts not liable to hail. If liable to hail, prune, as far as possible, so as not to have young shoots, nicely coming away, smashed with hail." (*Rose.*)

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looks upon the management as a grand success. Ten years afterwards the garden may be all but worthless, as a result of forced growth, close pruning, etc., etc., and if recoverable at all, the place can only be brought back to condition by a systematic course of heavy and collar-pruning and nursing of the bushes for long after. While we are fully aware that, under present commercial conditions, if a garden be made to produce its maximum, yet that maximum should be judged not by the standard of what it can do in one or two particular years, but by what it can keep on doing for a considerable number of years. Hence we argue that nursing the bushes, even to the extent of leaving them quite unpruned for a season, after heavy pruning, is wise and profitable even if it means the loss of a part of the crop which might otherwise be immediately obtained.

The question of the further treatment of the bushes will be spoken of under collar-pruning. *Conf. with paras. 51-57.*

Single stump pruning.

50. It has already been stated that if it is necessary to cut so low as to destroy the framework of the bush, or, in other words, to leave nothing but a single stump with or without a branch or two on top of it, then there is a good deal to be said for collar-pruning at once.

VI.—Collar-pruning.

COLLAR-PRUNING. The collar.

51. Theoretically the collar of a plant is the imaginary point of union between the root and stem. If the skin be peeled off a pea or bean it will be found that the contents divide into two large portions and that the halves may be seen to be hinged together by the embraced embryo. The two fat structures are the first leaves of the infant plant, greatly swollen by being made the store-houses of the food required for generation. The point of union of these seed-leaves to the embryonic axis is the true collar; the lower extremity of that axis becomes the root and the upper the stem. The most marked difference between the root and the stem lies, however, in the fact that the former (as already fully explained), has assigned to it the function of absorbing food from the soil. But it is commonly stated there is another difference, namely, that the root has no buds and cannot, therefore, be used as cuttings in the propagation of the species. Root-like structures, possessed of buds (such as the eyes of the potato), are pronounced to be underground stems, not roots. The distinction here indicated is so true of the greater

The embryo.

The root.

COLLAR-PRUNING. Underground stems.

number of plants, however, that when roots are found capable of independent growth they are often at once assumed to be underground stems and not roots.

52. The fear entertained, by many planters, against collar-pruning is that they run the risk of cutting below the collar, as defined botanically, and thus of killing the plant. The answer may be given that a good many plants would seem to produce, below the actual collar (or point of origin of the seed-leaves), structures that we must define as roots, but which, nevertheless, can and do bear buds. The tea plant possesses this property. Let a bush, found growing on root stilts, owing to the surface soil having been washed away, be severed, so that the separate roots remain projecting out of the ground, and we venture to think a good few will shortly thereafter be seen to throw out shoots. On the faces of roadway cuttings, roots, often 3 feet below the level of the soil, may not infrequently be seen to bear shoots. From these and such like examples, it may fairly be inferred that the risk of cutting below the theoretical collar is a remote contingency. Moreover, in transplanting, seedlings are invariably placed in their new positions with a considerable portion of the stem below ground.

Root budding.

Variations in meaning.

53. The term collar-pruning has had however a very loose signification up to the present in Assam, which is the only district in which the process has been at all common. It might mean on the one hand that the entire bush was cut away so as to leave a stump of the original stem that might be from 1 to 6, or even 12 inches above ground. The distinction between the latter and the condition designated "heavy pruning" was simply in the fact of only one instead of several stumps remaining. Collar-pruning was thus through the common stem instead of across its main branches, irrespective of position in relation to the ground or rather to the roots. It might, on the other hand, mean that the plant had been sawn off level with the ground, or it might in a few cases indicate that a hole had been dug, search made for the collar, and the cut made where this was supposed to have been.

High collar-pruning.

54. The merits of these various processes is extremely unequal. Take the first case. The result of high "collar-pruning" (so called) is in many cases the production of a stump, rotten in the centre, and bearing whatever foliage there is from a shell not one

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COLLAR-PRUNING.

inch thick, the whole of the remaining part of the stump having been eaten by white ants, or destroyed by fungus. It does not need very wide travel among tea gardens in Upper Assam to find such cases, and in some gardens where the process has been systematically carried out in this manner, a majority of the bushes, in spite of tarring the cut surface, are in this condition.

It will be seen therefore that while we are in favour of collar-pruning in many cases, we can by no means approve of the method just described. If it is necessary to do more than heavy prune the bush across the branches without destroying the framework of the bush, there should be no question as to whether a stump, as described above, be left or whether the bush be cut right down to the ground. If the latter is done, it must be perfectly recognised that no appreciable yield ought to be expected in any case from such a collar-pruned bush for eighteen months, that in the meantime it will need the most careful attention, such as staking, very careful hoeing, it may be watering in a dry season, and even the presence of a chowkidar to keep off stray cattle, goats, etc. It must be recognised that collar-pruning is a most serious operation, demanding the expenditure of money in manure, attention and care. One often wonders that much of the collar-pruning that is done comes away at all: there is often so little care spent upon it! The most successful piece of collar-pruning we have ever seen was on the Brahmaputra Co.'s gardens, but here the plot was fenced, a chowkidar kept on the spot for months after the operation was performed, and every care was taken—a vast contrast with much that we have seen.

No yield for eighteen months, afterwards attention required.

Successful example.

55. ***Conditions of Collar-pruning.***—The best conditions, judging from all experience, for collar-pruning, may be summarized as follows:—

Conditions of collar-pruning.

(1) Collar-pruning should be made in January or at an earlier date. There is urgent need for experiments in the time of collar-pruning best suited for various climates and conditions. This must be one of the experiments to be done at the very earliest opportunity, but in the meantime the vast majority of the tests made indicate that early collar-pruning is best.

Time of pruning.

(2) The position of the section should be as low down as possible, preferably below, rather than above, the surface of

Low collar-pruning.

COLLAR-PRUNING.

the ground. It should *not* be covered with earth, as, contrary to what would have been expected, there seems under those conditions considerable difficulty in the plant forcing its new buds through the soil covering.

Collar-pruning preferred with single stem.

(3) Where the heavy pruning indicated involves leaving a single stem standing above the ground a few inches, collar-pruning is usually preferable, though, as stated above, the time when this should be done in various districts urgently needs investigation.

Paint exposed sections.

(4) The exposed sections should be painted with vegetable tar (*not coal tar*) or Gondal fluid, to form a hindrance to the attack of white ants, and other insects or even fungi. The advantage of such applications is doubted, it is only fair to say, by a good many planters.

Manuring essential.

(5) Collar-pruning *involves manuring or top-dressing as an essential part of the process.* We think this is best done with cattle manure, the year preceding the application of the saw, unless good bheel soil is available, when this might advantageously replace the cattle manure.

(6) The cut should be made in a slanting direction and on the lee side of the stem (to the point of greatest rainfall). The bark on its commencing to grow forms a rim around the exposed sections of wood, which must of necessity become a saucer or shallow depression to retain water, that would prove injurious were the section made on the level.

Exceptional occurrence.

56. It must be recognised that collar-pruning should be, in a well managed garden, an exceptional occurrence. Its necessity is often the result of previous bad pruning, and though it is often necessary in old gardens, yet one should look upon it as a last resource when the wood of the bush is incapable of giving new growth of any vigour; and it becomes necessary to absolutely replace it by fresh stems and framework.

Teatment after collar-pruning.

57. ***Treatment subsequent to Collar-pruning.***—As we have said, collar-pruning involves the sacrifice of leaf for eighteen months, and even then the present yield should be sacrificed to the necessity of creating a new framework for a bush, just as with a young plant everything must be given up to make the bush. After two years

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we should be in favour of pruning the new growth down to a point which would allow future pruning to take place below—say 12 to 15 inches from the ground, and then light pruning could take place on top of this for a considerable number of years. These figures will vary for district and for conditions, and it would be impossible to lay down a law which would be everywhere applicable.

VII.—System of Pruning.

58. It would seem well to insist here that pruning is the most important operation in the garden during the season. It is at the pruning time to a large extent that a garden is made, or that a garden is ruined. Given the best soil, the best type of plant, and the best conditions of working, a constant change of system or a radically wrong system will so ruin the tea that a time will come when it will no longer be possible, either by pruning or by treating the soil, to bring the bushes back to anything like a reasonable yield. Such tea must be uprooted and replanted, or abandoned. But it seems a great pity that tea should be allowed to get into such a condition, and it would almost seem, if such a system were feasible—and we hardly see why it should not be—that a plan should be laid out ahead for five or ten years for pruning every plot often, and change of this, whatever manager were in charge, should only be allowed for some very special reason. The present system of going round each plot with a knife in December, and there and then deciding the year's pruning without reference to the past history of the bush is, we think, far too casual an arrangement for an industry in which the bushes represent both capital and stock-in-trade.

Pruning plan laid out ahead.

59. We would go even further than this and say that we fancy that it would be true economy to spend more money on pruning than is at present usually the case. The unit of consideration should be the bush and not the plot, and each bush should be pruned according to its own merits as nearly as can be done under the peculiar conditions of the tea-industry. Objections are at once raised and we recognise their importance.

Should often cost more.

In the first place it is said that it is impossible to pluck a plot, variously pruned, in the early part of the season. But is not the old system of plucking to a measure now feasible? We abominate the

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Difficulty of plucking variously pruned tea.

system of pruning to a measure, but plucking variously pruned bushes to a measure is an altogether different thing. It saves the low pruned bushes; it plucks the normally pruned bushes; and it strips the unpruned bushes which can bear it.

Difficulty of uninstructed labour.

The second and most vital objection to careful pruning is the impossibility of getting an uninstructed labour force to prune as one would wish. Speaking as outsiders, we should have to accept this objection, were it not for the fact that gardens exist where intelligent pruning is followed out. In one, for instance, trained sirdars go through their respective portions of the garden and fasten a stake bearing a coloured string alongside of each bush that would be required to be pruned in a particular way. The manager follows and examines enough of these to see that his ideas were being carried out, and then coolies follow, each pruning his own coloured bush in his own way—a method which demands no more skill from the coolie than the ordinary system, and merely asks a number of intelligent and trained sirdars—*together with adequate supervision.* It is only fair to say that many of the most successful planters in Assam deny the possibility of getting the individual pruning well done, however complete the supervision may be. In any case, in a young garden the demand for individual treatment will be very slight if the original plants were carefully selected.

Supervision necessary.

The impossibility of this supervision is the third objection made—and exactly its force we can perhaps hardly gauge. But if plucking can be so closely watched, as it is in many cases, that any woman plucking badly is detected almost with certainty, it seems hardly an impossibility to overlook the much more easily supervised pruning. The different pruning of different bushes in one plot will be a difficulty in an old garden, but in a young and well managed property, planted with selected seedlings, it ought to give very little difficulty as the plot will demand pruning almost exactly alike all over.

Pruning a scientific operation.

60. But what we want to insist upon is that pruning is a scientific operation of the utmost importance and delicacy, and one with paramount influence on the future and the permanence of the property. When this is recognised, as we believe it will be in the near future, we shall no longer see money spent in a niggardly manner on this business, and a month later be asked by managers how to employ their coolies at all as has often been our experience; but

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pruning will be elevated into the most important operation of the year, demanding the all but constant presence and supervision of the planter, and all the skill of which he is capable, both in the treatment of the bush for the year in question, and in the preparation of a basis for future yield—perhaps ten years ahead.*

APPENDIX.

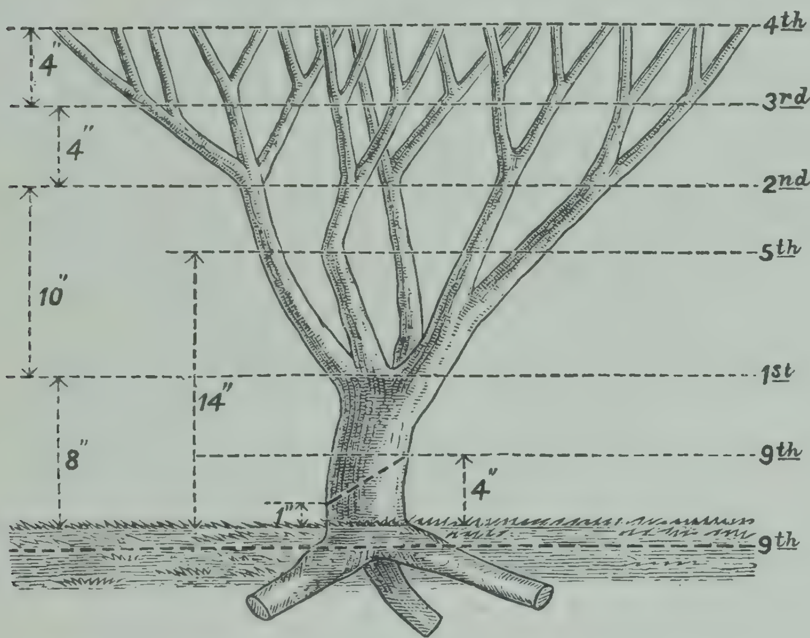

Fig. 2.—Representation of First to Ninth Prunings.

On Mr. L. Alexander's System.

We include here an example of a system of pruning the tea bush in its early years which represents what has been in vogue a good deal in some parts of Upper Assam. It consisted in the following course:— **Example of pruning your bush.** ***Conf. with paras. 12, 13.***

1. Bushes are cut to 8 inches when three years old. Here we prefer 6 inches or even 4 inches for Assam *jats*, and think that two years old is better than three.

2. Prune 10 inches above first pruning or 18 inches from ground.

3. High prune 4 inches above the pruning No. 2. We do not see why 4 inches are left: 2 inches seem amply sufficient. ***Conf. with para. 32.***

* We have to express our obligations to quite a number of planters who have been kind enough to give us the benefit of long practical experience in connection with this subject. To Messrs. Showers (of Cinnamara), W. N. Edwards (of Majulighur) and Temples (of Moabund) in Assam, and to Messrs. Rose (of Doloo) and Lennox (of Luskerpore) in the Surma Valley we are especially indebted in this connection.

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CAMELLIA Thea.

Principles of Tea Pruning.

4. High prune 4 inches above the pruning No. 3. Our remarks under No. 3 apply.

5. Go back on straight wood 4 inches below No. 2. We fail to see, given good soil, why it is necessary to go back at this stage. It should be possible to go up at least three years more. Again, if it is decided to prune back, why cut off 4 inches below pruning No. 2 ?—2 inches should be ample.

6. High prune 4 inches above pruning No. 5.

7. High prune 4 inches above pruning No. 6.

8. High prune 4 inches above pruning No. 7. The remarks under No. 3 apply to all these cases.

Conf. with paras. 7, 47. Conf. with paras. 53, 55.

9. Cut down the bush 4 inches from the ground. We totally disagree with this pruning. First, it destroys the framework of the bush, and hence should not be necessary for a considerable number of years : and second, it leaves a single stump. If it is necessary to cut so low as this, the bush should most probably be collar-pruned, but this measure ought not to be necessary for many years ahead.

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G. I. C. P. O.—No. 2681 R. & A.--3-2-1903.—2,230.—P. M. M.

THE

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(Crop Disease and Pest Series, No. 7.)

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SOLANUM TUBEROSUM.

(POTATO DISEASE.)

[*Dictionary of Economic Products, Vol. VI., Pt. III.*, S. 2330.]

Other DICTIONARY articles that may be consulted :

Fungi and Fungoid Pests, *Vol. III.*, **F. 475.**

also

The Agricultural Ledger, 1893, No. 4; 1895, No. 20.

POTATO DISEASES OF INDIA.

By E. J. BUTLER, M.B., *Cryptogamic Botanist to the Government of India.*

INTRODUCTION.

INTRODUCTION.

There exists in India a good deal of scattered information regarding the occurrence of various diseases of potatoes in the country. This information is, however, somewhat difficult of access to those most directly interested, being buried in Departmental records or found here and there in the Proceedings of Societies or in Scientific Journals. Furthermore there is much misconception of the extent to which disease is responsible for the generally poor quality which characterises the native-grown vegetable. This may be found not alone in the mind of the native cultivator, who, as is his way, puts down every untoward circumstance that afflicts his crop to a deficiency or an excess of rainfall, but also amongst Europeans who may happen to be brought into touch with potato-cultivation and who incline to ascribe all failings to the agricultural shortcomings of the raiyat. No doubt the climate and the methods of the cultivator have something to do with the state of affairs, but I think it can be shown that the use of tainted seed year after year and the consequent prevalence of disease almost universally throughout the country is a far more

Literature not readily accessible.

Mistaken views as to cause of poor quality.

Result following use of tainted seed.

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INTRODUCTION.

important factor. Again, even where specific disease is recognised to exist and is not confounded with unfavourable climatic conditions, the cultivator admits his helplessness and wrongly believes in the futility of precautionary measures. So mad a practice as that recorded below from Farukhabad, where the diseased tubers of one year's crop are habitually set aside for the next season's seed, can only be explained by a total want of understanding of the particular circumstances which give rise to disease and a fixed idea that such things are beyond control. For one does not find the cultivator as a general rule adopting practices, knowingly, which will result in an inferior crop. Once show him that he can diminish his losses from disease by a certain practice, or by the growth of a particular variety, and he eagerly avails himself of the information. In Poona the produce of the newly imported seed on the Government Farms which at first resisted the blight prevalent in that neighbourhood, was rapidly bought up at prices far exceeding that which any other seed would fetch. Therefore, that in many places disease is allowed to prevail unchecked, without the slightest effort to control it or to mitigate its effects must be due more to ignorance of the means than to a want of appreciation of the necessity. But it so happens that experience gained in many countries has proved the potato to be one of the crops that most repays the treatment of its diseases. Not only has the use of Bordeaux mixture for the **Phytophthora** blight proved efficacious in saving the crop in bad years; but it has been found that the practice of spraying is agriculturally a sound one, even when no disease appears. For, on account of some action not yet quite understood, the use of the fungicide increases the size and weight of the tubers, and the value of the additional yield thus obtained about covers the cost of the application. It is a case of Accident insurance in which the premium is returned each year. In many of the potato-growing districts of France, Belgium, and America, spraying has now become one of the routine operations of cultivation, and it may be said to have passed into an axiom in these countries that in the successful cultivation of potatoes, successful treatment of disease occupies the first place. It is perhaps too much to hope that spraying is a practice likely to be widely adopted in India, at any rate in the near future, but it is, fortunately, not the only means by which disease may be lessened. The choice of seed, the control of irrigation and a number of measures directed to improve what may be called the sanitation of the plant are but little less important, and it is in the observance of these that I believe lies the chief hope of dealing with severe outbreaks of disease.

Ignorance of disease and fatalistic notions of local cultivators.

Imported seed raised at Poona.

Potato disease amenable to treatment.

Spraying improves the tubers.

Largely practised out of India

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Potato Diseases of India. (*E. J. Butler.*) **SOLANUM tuberosum.**

INTRODUCTION.

For the reason that it appeared to be of interest to endeavour to give a historical account of the appearance of disease in Indian potatoes so far as the imperfect records go, and to give some idea of the extent and nature of the blights, I have gathered together the information to which I have had access. I have also had occasion recently to examine a considerable number of specimens of diseased plants from various parts of India, which have enabled me to check the information thus gained and in several cases to add to it. The examination of these specimens shows that disease of one kind or another is present almost wherever potatoes are grown in the country. In the more humid areas such as Assam, Bengal, the Eastern Himalayas and the Nilgiris, the prevailing blight is, as might be anticipated from its known preference for damp climates, that caused by the deadly **Phytophthora**. In the drier climates of the Deccan and Gujarat the so-called "Bangle blight" is found. But while the former appears to be steadily increasing its area of distribution and to be acclimatising itself to districts such as the plains of Bengal, where one would not have expected it to survive, the latter appears to spread more slowly, if at all. It has certainly failed to obtain a footing in Bengal though introduced there several years ago. These two are the most important diseases but several others are found. Since their distinction is necessary for the treatment, which varies in each individual instance, an account of the signs by which they may be recognised has been given. It must be admitted, however, that without the microscope, diagnosis is often difficult or even impossible, and in cases of doubt it is better to obtain an expert opinion. Finally, a summary of the treatments adopted in other countries and of the "Sanitary" precautions found advisable (such as the methods of storing recommended where the presence of diseased tubers is feared), is added. It is not to be expected that these recommendations will be found, as they stand, entirely adapted to Indian conditions, but they should certainly be capable of modification, in intelligent hands, in such a manner as to admit of application to particular cases. The only series of systematic experiments connected with these diseases that has been carried out in this country, so far as I am aware, should be of great value as a guide. I refer to the experiments undertaken at Poona in 1892 and 1893 with regard to the "Bangle blight" of that district, by the Department of Land Records and Agriculture, Bombay.

In India disease is generally prevalent.

Phytophthora. "Bangle" Blight.

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PHYTOPHTHORA INFESTANS.

CHAPTER I.

Potato blight caused by the fungus Phytophthora infestans *de Bary.*

First appearance.

1. ***History of the disease.***—The disease which is universally known as the "Potato disease," though by no means the only one to which potatoes are liable, first attracted general attention in Europe in 1845. For several years previous to this, references to a disease in potatoes were common in many countries: in France, Belgium and Germany in 1840 and 1841; in Norway, Denmark and the United States in 1842, in which year also an account of it was published by C. von Martius in Munich; in Canada and Italy in 1844 when it was evidently well established in most countries in the Old World and in North America. In 1845 a terrible wave of epidemic disease swept through every country from Russia westward to Canada, reaching in several to the height of a national calamity. It is said that in September of that year it was almost impossible to procure sound potatoes in England. Since then the pest has never quite disappeared in the area affected, fluctuating with respect to the virulence of its attacks in a remarkable manner. Of all the countries within that area Ireland has perhaps suffered most. There the disease is well known to have been the exciting cause of one of the worst famines of modern times amongst a population whose staple food was potatoes. In 1879 again the loss in Ireland from an exceptionally bad year was estimated at nearly £6,000,000. It still continues to be one of the worst diseases of cultivated crops with which the agriculturists of that country have to contend. Elsewhere, however, the virulence has decreased, owing in a great measure to the care with which the seed is now selected, and at the present day, in America at least, potato growers are able to keep it under reasonable control.

Connection with a fungus.

2. Though Montaigne and Berkeley in 1845 discovered the causal connection between a fungus and the disease, this view was not at first accepted. In 1846 prizes of £50, £30, and £20 were given by the Royal Agricultural Society of England for studies of its cause and treatment, and were awarded to investigators, who held that a fungus had nothing to do with it. Even in 1872 for a prize of £100 offered by Earl Cathcart, President of the Royal Agricultural Society, not one of the 94 essayists had a correct idea of its nature. In 1876, however, Professor de Bary re-established in a conclusive manner the fungal cause already indicated by him in 1863[1], and potato-growers in

[1] De Bary, Journal of the Royal Agricultural Society of England, Vol. XII, 1876, and "Recherches sur le developpement de quelques champignons parasites" in Annales des sciences naturelles, 1863.

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every country have been enabled, mainly by the work of the German scientist, to deal with the matter with a full understanding of its nature.

Nilgiris first locality affected in India.

3. In India, the Nilgiris appear to have been the first locality affected. The Honorary Secretary, Nilgiri Agri-Horticultural Society, writes to me (August 19th, 1902) in answer to an enquiry regarding the blight in that district:—

"The disease is no doubt the common Irish Potato blight, caused by a fungus. It has been noticed on these hills for the past 25 to 30 years, especially on the low-lying drained swamp lands. On new land and with carefully selected seed the damage is but little, though generally the disease is increasing. New imported tubers have been frequently introduced, and potato seed has been imported—not tubers—but these new plants are subject to the disease, unless entirely segregated on new land.

"It is considered useless to combat the disease, when once noticed on a field, with chemical sprays or otherwise—the fungus spreads so rapidly and is so general. It seems almost the same with the coffee leaf disease, for which no cure can be found, beyond high cultivation and manure to support the trees through the attacks."

Experience in the Nilgiris.

4. There appears to be a general agreement amongst the members of the Nilgiri Agri-Horticultural Society that the disease prevalent in these hills is the common European one. Though we shall see later that another potato disease is known to exist in the neighbourhood of Ootacamund, still I think the above-mentioned view is correct. I have had no opportunity of personally seeing the blight, but a letter of **Major-General H. R. Morgan** printed in the Proceedings of the Society for the 10th August 1900, makes it very probable that **Phytophthora** really occurs there. In this, he states that, about ten years ago, the disease was so bad in some potatoes, the seed of which had been obtained from a large nurseryman in England, that even his tomatoes were affected. **Phytophthora** has been known in many cases to spread from potatoes and to attack the tomato, whereas the other serious Indian potato disease—Bangle blight—is not known to do so.

5. In a note on the disease, dated 11th August 1902, communicated to me by the Honorary Secretary, Nilgiri Agri-Horticultural Society, **General Morgan** says:—

Disease not known 40 years ago.

"Some 40 years ago there was no potato disease but then the tuber was only cultivated in certain places such as Kaity, Kulhutty and a few other places. I cannot say when the disease first appeared, probably about 25 years ago, since which time the cultivation of the potato has become almost universal amongst the Badagas, the Subbies buying the produce. In the last three years the disease has spread. It appears as a blight, the plants droop and bear but small

Badaga cultivators.

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tubers. I soaked my seed potatoes in a solution of sulphate of copper, strength about 5 per cent; this had some effect. I also powdered the stalks when drooping with sulphur. The Badagas use no remedy and suffer accordingly."

Deterioration of produce.

6. In the *Proceedings of the Nilgiri Agri-Horticultural Society* reference is made from time to time during the past few years to the deterioration of potatoes in the district. It is generally attributed to inferior seed, continued cultivation in the same fields, and disease. The Badaga cultivator seems to be quite aware of the value of new seed and tries to get it from Bangalore; but he is habitually cheated, some of his own crop being held over from last season and re-sold to him as good Bangalore seed. A more potent method of inducing disease could not be imagined, for apart from the danger of seed-infection, the potato is one of the plants which most require constant change of seed to preserve its vitality and power of resistance to disease.

Need for fresh seed.

7. In a letter regarding the establishment of an experimental garden in the Nilgiris, from C. M. Mullaly, Esq., I.C.S., Acting Collector of the Nilgiris, to the Secretary to the Commissioner of Revenue Settlement Land Records and Agriculture, Madras, dated 1st September 1901, and printed in the *Proceedings of the Nilgiri Agri-Horticultural Society's Meeting* of October 25th, 1901, it is stated that potatoes form a very large proportion of the Badaga cultivation, and that it is scarcely possible to get any really good potatoes in the district, nearly all being diseased by a fungus.

Good potatoes not now found in the Nilgiris.

Disease very prevalent.

8. It is certain therefore that disease is very prevalent in the Nilgiris and is extending its ravages, and a part at least of the damage is to be attributed to **Phytophthora**.

Introduction by imported seed.

9. From what is known of similar cases it is probable that the fungus was first introduced there in imported seed from Great Britain. Infection of the tubers usually occurs, as will be described below, while the disease runs its course, and the planting of infected tubers is perhaps the most frequent method of propagating the pest. It has been ingeniously supposed that the first introduction of the disease into Europe took place from South America, the home of the potato, on the shortening of the time required to convey tubers from the New World to the Old by the introduction of steam. The disease is known to occur in the Andes, and probably **Phytophthora infestans** existed there for centuries before its appearance in Europe as a parasite on the wild species of **Solanum** which were the ancestors of our cultivated plant. That it was not known in Europe at an earlier period in the cultivation of the potato has been supposed to be due to the fact established by Jensen, that exposure to a temperature of over 77°F. for any length of time is fatal to the

Original home of the disease.

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PHYTOPHTHORA INFESTANS.

Spread dependent on temperature.

fungus. Until the introduction of steam the parasite was unable to cross the zone of tropical temperatures intervening between the Andes and Europe. The advance of the disease has been eastward since that time, and it seems probable that it has been conveyed into India in somewhat the same fashion as into Europe. In Australia, separated from Europe as it is by a long stretch of high temperatures, **Phytophthora** is probably as yet unknown, a disease at first supposed to be the common European one having been shown by **Mr. Tryon** in Queensland, to result from a bacterium within the tissues of the stem.

Darjeeling next infected.

10. Darjeeling appears to have been the next locality infected in India. Potato cultivation in the hills of that district had long been of considerable importance. Before 1883 many thousand maunds were annually exported to the plains. In 1884, 14,500 maunds were so exported.* Since that time potato cultivation has very greatly declined, and this has been almost entirely due to disease, which broke out first in 1883, shortly after the introduction of English varieties to Darjeeling. The disease spread through the district and Sikkim and is reported to cause serious damage also in the adjoining States of Nepal and Bhutan. As we will see below, it has not remained confined to the Eastern Himalayas but has spread westward as far as the Kumharsain State, north of Simla, and eastward to Assam. Cultivation of English potatoes is stated by **Babu N. C. Choudhury** to have extended all through Sikkim and into Nepal and Bhutan, the tubers being largely sold in the Darjeeling market for the use of the European residents.

Decline of potato cultivation.

Extension in the Himalayas.

Danger of importing seed.

11. In the introduction of any large quantity of seed tubers from an infected area, such as Great Britain, the danger of introducing disease is far greater than appears on the surface. And this for two distinct reasons. In the first place, even in years of slight damage from disease, the fungus can still be found on searching almost everywhere that potatoes are largely grown. For some reason, not yet explained by our present conception of the factors which induce epidemic disease, but certainly in part related to climatic influences, a time comes when the plant fails in its yearly struggle. Then we speak of a bad year for disease. It would be incorrect to assume that the failure is connected in any way with an unusual

Annual struggle against disease.

* Some of these particulars are taken from a "Note on experiments in potato cultivation in the Darjeeling Hills" by Mr. B. C. Basu of the office of the Director, Department of Land Records and Agriculture, Bengal, communicated to me by that Department. In this note also a brief account is given of experiments in checking the blight undertaken by the Department in 1888 to 1891, which however, owing to a combination of unfavourable circumstances, gave little practical results.

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prevalence of the fungus at the beginning of the year. Circumstances have been favourable for its multiplication and that is all. In other years, when damage has been slight, it is probable that as many foci exist from which the fungus may spread in the early part of the year as exist in the worst years of epidemic. But circumstances are against spreading and general disease does not occur. In other words every year is potentially a bad potato year in an infected country. A moment's thought will show that this must be due to a persistence of the fungus from year to year even when no outbreak of disease occurs to mark its presence. We will see below that the only way in which this can occur in the light of our present knowledge is by fungus infection of the tubers. Even in good years, then, a tuber here and there will be infected, and we have no means of separating the good from the bad before exportation. A second reason why importation is dangerous is that it is far from easy to discard diseased potatoes at the time of planting. Small tubers, at least, are usually set whole, and it is just these small ones which are liable to contain the fungus, since one of the effects of the disease is a stunting of the growth of the tubers. Even where sets are rigorously cut before planting, it is not certain that the presence of the fungus can always be detected by a blackening of the tissues.

Persistence of fungus in the tubers.

Some tubers always tainted.

Difficulty of discarding tainted tubers.

12. In any large import of seed from an infected area there is, then, at least a possibility and perhaps a probability of an introduction of the fungus. All that is wanting, afterwards, is a congenial locality for the establishment of the disease.

Conditions in Sikkim suitable to disease.

13. Such a locality appears to have been furnished in the Sikkim Himalayas. A few years after the introduction of the new seed, complaints of disease were general. For some time the native potatoes suffered most, appearing to be particularly weak in resisting the invasion of the fungus, but eventually, by 1886, deterioration set in also in the imported varieties, and in the Report of the Royal Botanic Garden, Calcutta, for 1886-87, it is stated that the acclimatised English potatoes of the Lloyd Botanic Garden, Darjeeling, had proved a failure. In the Report of the same institution for 1887-88, English tubers are said to be particularly liable to attack, and it is recommended that seed from Malta, Australia, or elsewhere, where the conditions of growth differ less widely from those in the Indian hills, be imported rather than English ones. The experience noticed here of the plant by which disease is introduced, itself proving for a time less liable to the disease than the native varieties of the locality, is not uncommon, and cannot be used as an argument in favour of the pre-existence of the fungus in Sikkim. Judged by its results, this well-meant effort at improving the quality of the crop must be held to have been most unfortunate.

Native potatoes first affected.

Deterioration of the new seed.

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14. Eastward the disease is next reported from Assam. In a note on "The Prevalence of Potato diseases in Assam," kindly supplied to me by Mr. B. C. Basu, Assistant to the Director, Department of Land Records and Agriculture, Assam, 1885 is stated to be the date of the first appearance of the blight in the Khasi Hills. In 1887 it raged in a virulent form, and almost the whole of the crop was destroyed. Planting on new land was advised, and the disease somewhat checked. In 1892 Dr. D. D. Cunningham, Special Assistant to the Sanitary Commissioner with the Government of India, examined specimens of the disease from the Khasi Hills and identified the fungus as **Phytophthora infestans**. In 1899 disease was again virulent in the hills, but was checked at the Government Experimental Farm, at Upper Shillong, by Bordeaux mixture. Next year, however, the application of this preventative was unsuccessful owing probably to excessive rainfall, and the crop was defoliated. Some of the tubers from this crop were examined by me in April 1901, but beyond blackening of the tissues nothing definite was found. In July 1902 further specimens of complete plants were received from Shillong and **Phytophthora** found in quantity on the under-surface of the leaves. The history of the attack in this case was similar to that of the previous year, the crop dying out several weeks before it was due to ripen. The leaves turned black and fell off with great rapidity, so that within a week or ten days the entire crop was stripped, leaving the green stalks standing quite bare. Though it was stated that when forwarded the tubers were not discoloured, still on receipt in Dehra Dun, 50 per cent. were found blackened in the interior, a result corresponding with the observations of the previous year. Bordeaux mixture was again unsuccessful, owing no doubt to heavy rainfall.

Disease in Assam. **Virulent in 1887.** **Identification of the fungus.** **Treatment.** **Nature of attack.**

15. In the Reports of the Department of Land Records and Agriculture, Assam, it is noted that imported seed from other districts often resists the disease for some years, eventually succumbing when apparently established. This important fact will be returned to again. The crop from which the diseased sample sent to me was taken was raised from acclimatised Naini Tal seed, the original seed stock having been imported into the district several years ago. Some half dozen other kinds of potatoes raised from newly imported seed on the Farm, did not show the brown spots, and were quite healthy. Interesting information is also given in these Reports and by Mr. Basu, regarding the methods of cultivation in the Khasi Hills. Two crops are usually got in the year, the same land being used constantly year after year. The second crop is generally poor and is largely used to supply the next season's seed. Small tubers are much used for seed, and though the Khasia cultivator recognises blackening as a sign of disease, blackened tubers are freely used in

Resistance of new seed. **Khasia cultivation.**

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planting. Small tubers are planted whole and are probably often diseased. No precautions whatever appear to be taken against the disease, and it is not surprising that "bad years" are frequent. In every respect the cultivation practised in Assam must favour the pest.

Probable infection from Sikkim.

16. The first outbreak of disease in Assam, two years after its appearance in the Sikkim Himalayas, points to infection from that source, either by exportation or by continuous extension through Bhutan.

Disease in Nepal.

17. In the other direction, westward, along the Great Range, the disease has also progressed. It is reported to have extended through Nepal. Dr. Cunningham in a paper on "Blights affecting Potato-crops in India" published in the *Scientific Memoirs by Medical Officers of the Army of India*, in 1897, mentions that he had received specimens of **Phytophthora** from Kumaun. This proves that it has reached that locality. I have been unable to obtain definite information as to the extent of its ravages in this district, which is a large exporter of Potatoes. The Deputy Commissioner of Almora reports that a potato disease which appears to be Irish blight (**Phytophthora**), occurs at times in the Almora district. The Deputy Commissioner of Naini Tal states that "about 20 years ago" (*i.e.*, about the time of the introduction of the disease into Darjeeling) "a blight destroyed nearly the whole of the crop of this district. In the vernacular it was simply said, 'Hawa se mar gaya.' Since then the species attacked apparently became extinct, or at any rate the fungus does not seem to have attacked the crop again. Other cultivators report what seems to be the supertuberation noted by Mr. Seers" (see below), "with consequent unhealthy condition of the crop, but anything like general disease has been unknown."

Disease in Kumaun.

18. Mr. Seers, Proprietor, Snow View Garden, Naini Tal district, writes in answer to the Deputy Commissioner's enquiries that "no such thing as Irish blight so-called exists in this Province." This is obviously a mistaken assertion for we have seen that Dr. Cunningham obtained it from there. If any one fact, in connection with **Phytophthora** is fully established, it is that the fungus does not leave a district which suits it, when once it has gained an entry into it as long as conditions of cultivation are unchanged; and probably no change short of entirely ceasing to grow potatoes could altogether exterminate it. The fungus is found in the Himalayas, east and west of Kumaun, and must certainly exist in Kumaun itself. That it does not cause extensive damage there, is a fact for which the cultivators have reason to be thankful. But it must be an ever-present danger.

Supertuberation in Kumaun.

19. While stating that any general specific disease does not occur in Naini Tal district, Mr. Seers remarks on a fact which gives a possible explanation of the failure of Naini Tal seed, in the last two or three years, in Lower Bengal. A late monsoon has, for several seasons, induced supertuberation in a great part of the crop

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in Kumaun. Seed from tubers which have thus sprouted into a secondary tuber-production is most indifferent, and the produce is certain to be weak. If these tubers were, in addition, diseased, or if the disease had been introduced in other seed, planted contiguously, then they would be particularly prone to take it severely. When disease broke out in Lower Bengal in 1900, the Naini Tal seed which is so largely grown there, fell an easy prey to it.

Disease not severe in Kumaun.

20. On the whole then, though **Phytophthora** undoubtedly exists in Kumaun, still it is evident that general disease from it does not occur; and there is nothing to show that Naini Tal seed can be accused any more than seed from any other infected area of first conveying the disease to Bengal. It is merely clear that the Naini Tal produce was less resistant to the disease than other varieties.

In Kumharsain State.

21. Enquiry further west has led to the detection of **Phytophthora** disease in the Native State of Kumharsain, north of Simla. Specimens of a disease stated to exist in this locality were received by me through the Director, Department of Land Records and Agriculture, Panjáb, in September 1902, and showed abundant fructifications of the fungus on the under surface of some of the leaves. The blight is said to occur every second or third year and is noticeable in years when there is heavy rainfall. The external signs of it are similar to those of a disease reported to be prevalent this year at Phágu, Keonthal State. It is believed that this disease attacks the crops every year in Keonthal in the month of August. The first signs of it are that the leaves of the young plants turn yellow and begin to dry, and by the end of August rot and fall away. When the potatoes are dug up it is found that the roots in the majority of cases are rotten and the potatoes themselves discoloured and, in not a few cases, quite rotten and inedible. I was unable to find **Phytophthora** in the specimens received from Phágu, but have little doubt it was present in the crop from which the specimens were taken. As a matter of fact it is not easy to get good specimens from such a locality. Since the fungus appears chiefly on the leaves, and these rapidly drop off, plants in the early stages alone are satisfactory for examination. As far as I could judge from the sample received only quite dead stalks were gathered. Cultures tried from the blackened tubers gave negative results probably owing to the exposure to high temperature on the journey through the Panjáb having destroyed the vitality of the fungus. I am not disposed to attach great importance to the negative result of examination of the specimens from Phágu, while the positive proof got from the similar disease in Kumharsain, by the detection of **Phytophthora** on the leaves, makes it probable that at Keonthal, as at Kumharsain, the disease is established.

Identification of the disease.

In Keonthal State.

Description of attack.

***Phytophthora* not found in Keonthal specimens.**

Probably exists.

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First appearance in the plains.

22. In the great area between the Himalayas on the north and the Nilgiris on the south, potato disease due to **Phytophthora** was reported for the first time last year. In a letter from the Officiating Director of Land Records and Agriculture, Bengal, to the Superintendent, Royal Botanic Garden, Calcutta, dated 15th February 1902, it was stated that a serious potato blight had broken out in some parts of the Hooghly district. Specimens were received by me for examination through the Department of Land Records and Agriculture, and also from the Assistant Reporter on Economic Products. They were found to be badly attacked by **Phytophthora**.

Hooghly district.

Local enquiry.

23. The outbreak was investigated locally by **Babu N. C. Choudhury**, a Travelling Overseer of the Department of Land Records and Agriculture, Bengal, who afterwards visited Darjeeling where the first potato crop had also been seriously diseased. A copy of his report was kindly furnished me by the Officiating Director, Land Records and Agriculture. The following particulars are taken from it.

Confined to Hooghly.

24. The disease was reported on the 30th January 1902, by the Collector of Hoogly, from thana Singur in the Sub-division of Serampur. **Babu Choudhury** found it confined to the Hooghly district, which is the most important potato-growing district in Lower Bengal. Burdwan district, the next most important in regard to potato cultivation, and 24-Parganas, where cultivation is only nominal, were unaffected.

Spreading from a centre.

25. The blight first appeared in the Singur thana, and spread to the surrounding villages in thana Haripal to the west, Dhaniakhali to the north-west and Chanditolla to the south. Thanas Jagatballavpur and Amta in the Howrah Sub-division and Tarakessur to the west of Haripal were also slightly affected. Generally the greater the distance from thana Singur the less the disease. Mogra to the north of Dhaniakhali was free from it.

Estimate of loss.

26. It was first observed in 1899-1900 in a few fields of thanas Singur and Chanditolla. The damage was slight. The next year, 1900-1901, it was worse and was present in thana Haripal. Last year it had still further extended and was extremely virulent. It was estimated that the loss was in many cases 50 to 75 per cent, only 15 to 30 maunds of indifferent potatoes being got, instead of 60 or 80, per bigha ($3\frac{1}{30}$ bighas = 1 acre). Late sown potatoes were most affected, those which ripen in the beginning of January escaping. Naini Tal imported seed, which ripens in February, suffered most, and these potatoes occupy a larger area in Hooghly district than all the other varieties put together. As usual, mention is made of excessive or unseasonable rain as favouring the disease, it having fallen in November 1900, December 1901, and November

Varieties affected.

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Conditions favouring disease.

1902. Probably a more potent factor is the excessive irrigation described as in vogue in thana Singur. The cultivators here irrigate at intervals of about 6 days so that the soil is kept saturated. This, as we shall see below, is most unwise when disease is to be feared. Mention is also made of the cultivators' belief that the disease is due to the western winds, which, as Babu Choudhury suggests, may have a favouring effect by reducing the cold at the growing season. Moist, foggy weather such as is common in Calcutta at this season is known to be one of the most frequent precursors of the disease in other countries, but no mention is made of it in Hooghly, and I do not know if it accompanies the west winds spoken of.

Disease previously unknown.

27. Before 1900 the disease was unknown to the cultivators. Another disease which in former years did much damage, was called by them *Dhasa*, a term also applied by some to the new disease. This former disease appears to have been that described below as "Bangle blight," the cause of the worst damage to potatoes in Bombay Presidency.

A former disease.

Vernacular names.

28. Various names have been given in the vernacular to the **Phytophthora** disease. In Singur it is known as "Dhasa" or "Marka" as the plant rots or dies. In thana Chanditolla it is known as "Tipi" as its first sign is a spot. In Nalikul it is called "Topadhora." It is sometimes called "Marmaria" as the plants are supposed to fall down as rapidly as trees are blown down by a storm.

Varieties grown in Lower Bengal.

29. It would appear from Babu Choudhury's report that the varieties of potatoes grown in Lower Bengal are chiefly the following:—

Patna commanding the lowest price, country, Naini Tal, Umballa and Bombay. Naini Tal, Patna and country which are chiefly grown in Hooghly district were all similarly affected with the disease, but, as mentioned already, the Naini Tal were the worst.

Cultivation.

30. As a rule the best fields of the cultivator are cropped year after year with potatoes. Those crops which were grown in fields selected for the first time were less attacked. The potato fields in the Hooghly district are manured with 15 to 30 maunds of castor cake and about 150 maunds of rotten cowdung per acre.

Disease not known elsewhere in India.

31. **Phytophthora** disease does not appear to occur elsewhere in the Plains or Peninsular area of India. Mr. Mollison, Inspector General of Agriculture, does not believe it exists in Bombay, where the second of the two serious Potato diseases of India is chiefly found. In the Central Provinces potato cultivation is small and disease is apparently absent. From Burma two samples of diseased tubers have been received. One, of imported Darjeeling seed, from the Southern Shan States through the Officiating Reporter of Economic Products, Calcutta, and the other from Sima, through the Director, Department of Land Records and Agriculture,

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Burma. Both showed discolourations in the interior, but I could not detect the presence of **Phytophthora**. The tubers are being grown for further examination.

32. It would thus appear that with the exception of the recent outbreak in Lower Bengal, the Plains of India and the Deccan are free from the disease.

Difficult to understand the invasion of the plains.

33. It is not easy to understand how the fungus can ever have become established on the Plains of Bengal. The gradual extension from a centre at Singur, lasting now over three years, makes it, unfortunately, probable that the fungus has in some way managed to live through the hot season in the infected locality, and has not been introduced afresh each year. Such an occurrence is, so far as I am aware, unprecedented, as it seems to have been assumed that exposure to such a temperature as prevails in Bengal for several months of the year is fatal to the fungus. Jensen states, as a result of prolonged experiments, that exposure of the tubers to a dry heat of 100° to 105°F. for four or five hours is sufficient to thoroughly disinfect diseased ones. Later figures give 104°F. as the lower figure. The upper layers of the soil in Bengal are subjected to a much greater heat than this every year, and if a perennial mycelium, such as is found in diseased tubers, were to occur in the soil, it should be quickly killed off. It is possible that the cultivators reserve a portion of their crop each year for seed in addition to importing fresh seed, and this local stock may be stored in such a way as to escape the high temperatures of the hot season. In this way the mycelium could persist from year to year in the tubers, and pass in the growing season to infect an ever-widening area. But it seems clear that for the future no part of India can be held safe from invasion, and it will be surprising indeed if the blight does not extend into every province for the country.

Estimate of damage caused by *Phytophthora.*

34. ***Losses from the disease.***—It is impossible in most cases to form any estimate of losses caused by potato disease in India. The following figures from Bulletin No. 5 of the Assam Agricultural Department show that a great disease in exportation of potatoes from that Province has occurred since the blight appeared. The figures show the exports *viâ* the Brahmaputra and Surma Valleys taken together :—

Exports from Assam.

Year.	Maunds.
1884-85	103,536
1885-86	114,739
1886-87	109,502
1887-88	42,374
1888-89	26,405
1894-95	12,301
1895-96	8,296
1896-97	16,726

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35. It is, however, pointed out in the Bulletin, that it is uncertain how far the great decrease in exports since 1885-86 represents a reduction of the area under potato cultivation in the district, since it has coincided with the development of cultivation in Lower Bengal, and also since Kumaun potatoes have largely replaced Khasi varieties for seed within the last few years. At the same time internal consumption, especially on tea gardens, has increased. Still the consensus of opinion is that the area has greatly diminished since the appearance of **Phytophthora infestans** in 1885. The Khasia cultivators look with less favour on potatoes now than formerly, and it is not surprising that they have to a great extent abandoned its cultivation for other crops. The average yield is said to be only five-fold for the first crop and two-fold for the second. The product is of bad quality, and blackened tubers (as I can personally testify) are so common that it is rare to get a dish that does not contain several. Much of this deterioration is no doubt due to the disease.

Yield and quality.

36. In Hooghly, Babu Choudhury made a painstaking effort to estimate the loss caused by the disease last year. The following table drawn up by him shows the rise in price consequent on the appearance of the disease in potatoes of the Patna variety sold for the Calcutta market :—

Loss in Hooghly.

Price for Calcutta market.

	R	a.	p.	
1898	1	6	0	per maund.
1899	1	4	0	"
1900	1	4	0	"
1901	2	0	0	"
1902	2	0	0	"

37. That the price in 1902 was not higher than in 1901 is considered by Babu Choudhury to be possibly due to a great diminution of exports from Calcutta to Rangoon and Chittagong, a fall of from 16,000 maunds per month in 1901 to 5,500 maunds per month in 1902.

38. The diminution in yield appears to have been enormous. In 1900, 206,400 maunds were estimated as available for export from the Hooghly district; in 1901, 275,000 maunds were so available, and in 1902, 160,000 maunds only, a drop of 41·8 per cent. from the previous year. In many cases, Babu Choudhury remarks, the cultivators would not be able to recover the cost of either manuring or seed.

Exports from Hooghly.

39. *Symptoms of the disease.*—The external signs of the disease are not always the same, depending to some extent in the later stages on the weather, especially the degree of humidity, and on the association of certain bacteria, chiefly of the butyric acid group. In all cases the first sign of the disease is the appearance of small brown

External signs.

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patches on the leaves. These are found everywhere both at the edges and over the whole surface, and increase in size rapidly, coalescing with neighbouring patches. As the edges are attacked the leaves often curl up. Like the leaves, the petioles and stem are often covered with brown patches. When the air is humid, extension of these patches is very rapid, and a general softening or rot caused by a crowd of other organisms which follow in the train of the **Phytophthora**, occurs over the attacked areas of the plant. The extent to which this progresses varies very much. In some cases the leaves alone fall leaving the stalks standing for a little time quite bare. In others leaves and stalks fall over together in a rotten pulp. The odour which is often so marked in these last cases and which can be smelt for miles in Ireland in a bad year, is chiefly due to the butyric acid bacteria accompanying the rot.

Rotting. *Odour.*

Shrivelling of leaves.

40. In other cases, especially mentioned by French writers, it would appear that the brown patches dry up causing the leaves to contract and become deformed. This is probably the natural action of the fungus unaccompanied by any putrefactive organisms.

Organs of dissemination.

41. On the under surface of the leaves, the organs by which the fungus is disseminated soon appear. Their position is indicated by a sort of white haze visible on turning up a leaf at the margin of the brown patches. This haze is formed of a multitude of more or less erect filaments bearing spores or organs of multiplication, which can sometimes be seen in dry weather as a fine white powder mingled with the filaments. They spring from the main body or "mycelium," of the fungus, which consists of numbers of threads or "hyphæ" buried in the substance of the leaf and pushing everywhere between the cells.

Spores.

42. These threads, erect filaments, and organs of reproduction, which form all that we know of the fungus **Phytophthora**, merit a fuller description.

Microscopical characters.

43. In a thin section of a leaf taken just outside one of the brown patches, colourless hyphæ of the fungus can be seen under the microscope, squeezing their way between the green cells of the leaf tissues. They do not enter these cells as a rule, being apparently able to absorb the nutrient juices across the cell wall. In rare cases, however, short branches of the fungus perforate the walls and enter the cells to act as suckers, organs which are common in the other fungi allied to **Phytophthora**. But whether suckers are formed or not, the result is the same. The food material present within the cell is taken up by the parasite which at the same time probably excretes some poisonous substance capable of destroying the living protoplasm. Consequently death occurs with great rapidity. Where the fungus touches a wall the latter browns, and the

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brown colour extends along the walls to parts not yet reached by the threads. In the tubers, as is well known, these brown spots are usually strongly developed, but it must not be forgotten that many other causes induce a similar discolouration. As the cells are killed, the fungus continues its growth, dying out behind as it spreads into tissues as yet healthy and kills them in their turn. It is not able to live on dead matter, requiring as food the living substances of the potato or of a few other allied plants, such as the tomato, belonging to the SOLANACEÆ, and some of the SCROPHALARIACEÆ. When the under surface of the leaf is reached, tufts of aerial filaments emerge through the stomata or air-openings, which are found only in this locality. Some of these filaments are represented in fig. 1. These are the conidiophores or spore-bearing structures. As may be seen they are branched in a tree-like manner and often provided with little enlargements which give them a beady appearance towards the apex. At the tip of the main filament and of each of its branches a conidium or spore is developed. This is cut off by a septum formed a little way below its base, and, as the filament still continues to grow, the spore and its minute stalk are pushed over to one side and usually fall off. Ten or more spores may thus be formed during the growth of the filament, and the little enlargements just mentioned each indicate a place where a spore has existed and has fallen off. To represent the filaments as being provided with walls or septa at each of these enlargements as is done in some textbooks is erroneous. This portion of the filament is rarely septate, but the lower part of the aerial threads, and the hyphæ within the leaf, are sometimes divided up by walls placed at irregular intervals. These are never formed in the parts of the fungus which are still growing and are full of protoplasm, but serve to cut off growing parts from those which have finished growth and have been depleted of their contents.

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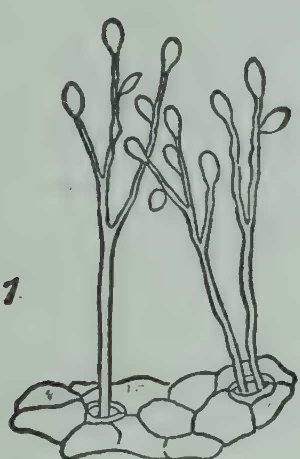

Figure 1.—**Phytophthora infestans** *de Bary.*—Portion of the epidermis of the lower surface of the leaf with two stomata through which project conidiophores bearing conidia. Magnified 100 diameters (after Percival).

Dissemination by spores.

44. *Dissemination of the disease.*—The spores which are thus thrown off from the tips of the tree-like conidiophores are the means by which the fungus is disseminated from leaf to leaf, and from plant to plant. Myriads of them are produced on the first infected plants in favourable weather. From these they are spread chiefly

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by the agency of the wind. We have only to consider the size and weight of the conidia, which measure about $\frac{1}{800}$ of an inch in their longest diameter, to realise how readily they can be blown about like powder. Each spore can reproduce the disease provided that it falls on a potato plant, and is supplied with the requisite moisture to allow of germination.

Germination of spores.

45. A **Phytophthora** spore can germinate in either of three ways. Usually on falling into a drop of water (rain or dew) the contents of the spore divide up into a number of parts (from six to sixteen); then the tip of the spore dissolves and each of the parts is expelled rapidly into the water (fig. 3). Here it assumes the shape shown in fig. 4, and two cilia or swimming organs are put out. By means of these, the little particles, now known as zoospores, are capable of moving about for a quarter of an hour or more in the water. Then they come to rest and each puts out a germ-tube which becomes a fungus filament. This process may occur for as much as three weeks after

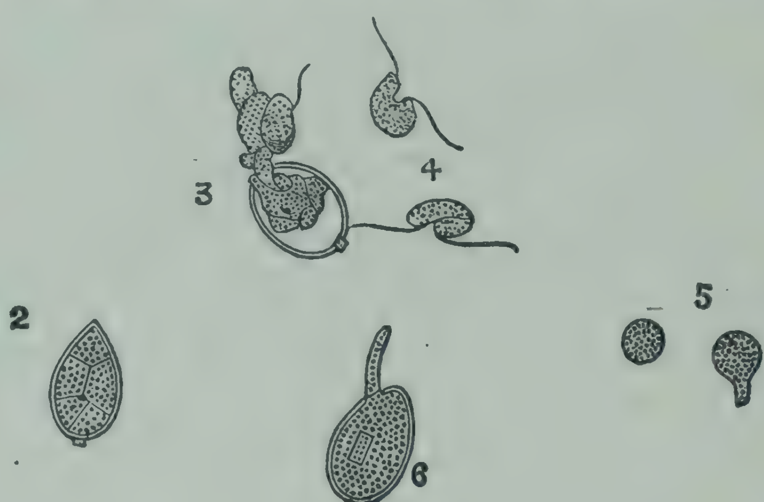

Figure 2.—**Phytophthora infestans.**—Ripe sporangium showing the zoospore origins already marked off. Magnified 390 diameters (after de Bary).

Figure 3.—Discharge of zoospores.—Magnified 380 diameters.

Figure 4.—Two zoospores in the active state. Magnified 380 diameters.

Figure 5.—Zoospores come to rest and beginning to germinate. Magnified 390 diameters (after de Bary).

Figure 6.—A conidium germinating directly by a germ tube. Magnified 380 diameters.

the maturation of the spores if the latter have not completely dried up. If the ripe spore has fallen on to the film of rain or dew which covers the surfaces of leaves and stalks in the moist weather which almost invariably accompanies bad outbreaks of the disease, the swimming spores go off in all directions, and form so many centres of infection. For the filament emanating from each of the zoospores has the power to penetrate the substance of the leaf or stalk in search of the food on which alone it can live. Once within the tissues

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it immediately begins its work of destruction, and growing vigorously soon reproduces the branched mass of threads above described in the interior of the plant. These swimming spores form a means of dissemination of the fungus apart from the air-borne conidia, since diseased and healthy plants are often in actual contact with each other in thickly sown fields, so that passage from plant to plant through the water becomes possible.

46. A second mode of germination is often found in which the conidium on falling on a moist surface puts out, itself, a germ-tube, instead of giving rise to a number of zoospores. This tube grows for a while and forms a new spore at its apex, which falls off in its turn and gives rise to zoospores or to a germ-tube.

47. A third mode is also found in which the spore gives rise, as in the last case, to a germ-tube, but this directly enters the substance of the potato plant without waiting to form a secondary spore.

48. The first of these three methods of germination usually occurs in spores which fall into water shortly after their maturation. The last two are found chiefly in older spores.

Spores can infect all parts.

49. Though the spores are only formed on the under surfaces of the leaves, their germ-tubes have the power to penetrate any part of the potato plant even the tubers, across their tough skins.

Infection of tubers.

50. It is usually held that infection by spores which have been washed through the soil into contact with the tubers, is the means by which the latter become diseased. Some consider, however, that extension of the threads takes place down inside the stem, and that they reach the tubers in this manner. Experiments seem to show that the former is by far the commoner way and that if the spores can be prevented from entering the soil the tubers will usually escape. Thus Mr. Carroll of the Glasnevin Model Farm, Dublin, succeeded by covering the ground under diseased plants with a layer of cotton wool in preserving the tubers from disease most successfully. Jensen's treatment of the blight is in part based on this belief.

51. When the tubers become infected they are sometimes destroyed in the same way as the leaves, with the difference that as bacteria are more abundant in the soil, so rotting is more rapid.

Dormant mycelium in tubers.

Very often, however, the fungus threads pass into a dormant condition without doing any great injury. Tubers containing dormant hyphæ show in their interior brown spots, due, as already said, to the power possessed by the growing fungus to turn brown the cells with which it comes into contact. On storage these tubers are often destroyed by rot. This is probably due to a weakened vitality from the presence of the fungus, which allows of the rotting bacteria to become established and to destroy the tuber, rather than to any direct growth of Phytophthora itself. It unfortunately happens, however,

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that tubers, to all appearance externally sound, may last through the year and be available for planting, though containing within them these dormant filaments. On germination, the fungus re-starts into life and growing up the newly-formed stem reproduces the disease.

Sexual or resting spores.

52. Most of the near allies of **Phytophthora**, amongst the fungi, are provided with another means than the formation of dormant, enduring, filaments, of persisting from year to year. This is the production of sexual spores which on fertilisation are capable as oospores, egg-spores or resting spores of living through long periods and of withstanding great variations of temperatures and dryness.

Not known in *Phytophthora infestans.*

For **Phytophthora infestans** these are not known, and if formed at all they must be extremely rare. An English botanist Worthington G. Smith claimed to have found them in 1875, but his evidence was inconclusive. De Bary, the great German mycologist, showed that part of Smith's specimens were produced by an allied fungus, **Pythium vexans**, and part were identical with a fungus described by Montaigne as **Artotrogus hydnosporus** which De Bary showed to be also a **Pythium** and called **Pythium Artotrogus**. In the tubers which I received from Hooghly, last year, I found considerable quantities of this last fungus, and was able to obtain it in culture free from the **Phytophthora**. The character of the threads of the two fungi is quite distinct and there can be no question of their being different things. The curious thing is that **Pythium Artotrogus** is usually found in conjunction with **Phytophthora infestans** and De Bary has suggested that it may be a parasite on it. It is, however, capable of growth apart from **Phytophthora**.

Two methods of infection known.

53. We see then that the fungus of potato disease has spread from continent to continent, and can persist from season to season, by means of dormant threads within the tubers, threads which can be killed by a temperature exceeding 104° F., and that each season it is disseminated from plants which have sprung from diseased seed by spores produced on their leaves. Also that these spores are delicate things, and at most can live for a few weeks and that only if preserved from drying. This knowledge enables us to indicate the lines on which treatment may be successful in checking the disease.

Principles of treatment.

Direct.

54. *Treatment of the disease.*—Treatment may be directed on the one hand to securing that tubers containing living fungus are not utilised for seed, and on the other to preventing the spores of **Phytophthora**, should they fall on the leaves of healthy plants, from germinating and thereby infecting them with the disease, or should they fall on the soil from passing down to the tubers. It may be said at once that no method of curing the disease once it appears on a plant has been devised, and that no potato has been produced as yet which is disease-proof.

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55. Besides direct treatment of this nature, aimed at the fungus, it is not less important to strive to improve the resistant powers of the potato plant by good cultivation and by the constant introduction of new varieties raised from seed. *PHYTOPHTHORA INFESTANS.* **Indirect.**

56. To secure the first of these requisites that tubers containing living fungus are not utilised for seed is unfortunately not possible in every case. Much may, however, be done to minimise the danger. Thus it must be self-evident that it is madness to use as seed, tubers which have been procured from a district known to have severely suffered from the disease in the last season. Thus, if seed from Darjeeling for instance, where the disease was severe last year, be imported into any other district for this season's sowings, it is natural to expect that the potential danger of a bad outbreak is considerable; for a number of tubers will be diseased, and all that is wanted is a suitable range of temperature, moisture, etc., to induce a large development of **Phytophthora.** If, however, disease has not been virulent for the last few years, the number of dangerous tubers will be proportionately lessened. Again, it is evidently a safer practice to use cut sets only, in localities liable to disease, if the seed be of a suspected quality. Unfortunately practical experience goes to show that small cut sets give poorer returns than the planting of whole tubers. But it should not be difficult in particular districts to balance the financial objections to the two practices, and to arrive at a decision as to whether it be better to obtain a larger outturn at the risk of inducing severe disease, or a smaller crop in which the danger from disease is lessened. I do not think there can be any doubt that it would pay the cultivators in Hooghly, for instance, for the current year, to cut all sets, planting only those which are unblackened, since, as we have seen, there is great danger in that district if climatic conditions be favourable, of severe disease. **The question of seed.** **Cutting the sets.**

57. A method has been devised by **Jensen** of Copenhagen of sterilising suspected seed tubers. He recommends that they be placed in vessels plunged into water at a temperature of 104° to 120°F. for four or five hours, a treatment, which he states as a result of numerous experiments, ensures the destruction of the fungus without in any way injuring the germination of the seed. Chiefly, it would seem, on account of the excellent results got by the use of Bordeaux mixture, which will be treated of below, this method of **Jensen** has not been much used. It might be worth a trial in districts where excessive rainfall renders the use of Bordeaux mixture both expensive and of doubtful efficacy by washing the mixture off the leaves as fast as it is applied. To be successful, however, it must be done generally throughout a district, if the potato fields lie at all closely together. Otherwise each untreated field will serve as **Jensen's hot water treatment.**

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a focus, from which spores can be blown to all the fields in the neighbourhood.

Bordeaux mixture.

58. To prevent the spread of **Phytophthora**, by means of spores, from plant to plant, only one method at the present day is considered to hold out a fair prospect of success. It is the spraying of the crop with Bordeaux mixture, first recommended by Prillieux and used by Jouet in France, in 1885. An exhaustive series of experiments was instituted by the Board of Agriculture in 1892 and 1893 throughout the British Isles and supplemented by enquiries made in the colonies and in other countries. The results were quite conclusive as to the value of the treatment when carefully carried out; and this has been the experience wherever the remedy has had a fair trial. Not alone does spraying check the spread of disease, but it also increases the yield of potatoes per acre by some action not yet quite understood but probably by preserving the foliage green, and in a condition of vigour for carbon assimilation, longer than would otherwise be the case. This increased yield in most cases covers the cost of the application even when no disease has appeared.

Nature of the mixture.

59. Bordeaux mixture (bouillie bordelaise) is a mixture of sulphate of copper and lime in certain proportions which causes the formation of copper compounds not yet clearly known. These are thrown down in the form of a fine precipitate, probably containing basic copper sulphate and copper hydrate. A clear liquid remains above free from copper.

Preparation of the mixture.

60. To prepare 50 gallons of this mixture the following directions may be useful. Weigh out 6 lbs. copper sulphate, break to powder and dissolve in 25 gallons of cold water by suspending in a piece of gunny sacking in the water. The latter must not be contained in a metal vessel but in a barrel or big earthenware pot. In another vessel weigh out 4 lbs. of fresh quicklime. Slake this gradually till it falls to powder and then add water up to 25 gallons. Let cool. Then add to the copper sulphate solution through a sieve so as to retain any lumps which would clog the sprayer, stirring vigorously with a wooden stirrer. A thick bluish liquid at first results, which on standing throws down a bluish precipitate leaving the upper part of the liquid clear. This clear liquid should turn blue red litmus paper, and should not give rise to a reddish precipitate on adding a few drops of ferrocyanide of potassium. If this precipitate appears some copper still remains in solution and may be injurious to the leaves. More lime should therefore be added. A convenient way of determining if copper remains in solution is to plunge a steel knife into the liquid, when, if a coating of copper is formed on the knife, more lime should be added. The mixture is now ready for use. It may be best applied

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by means of an Eclair Sprayer with the Vermorel nozzle,* the mixture being well stirred before use. Too much lime clogs the nozzle. Air-slaked lime may cause damage to the foliage. Application during the heat of the day may also cause injury. Two applications should suffice, one just before the disease usually makes its appearance and the other as soon as the first signs of it have appeared. The spraying should be thorough. At first it was thought necessary to spray the under surfaces of the leaves—a difficult matter,—but it has been seen above that infection can, and usually does, occur through the upper surfaces. It is here naturally that the great proportion of air-borne spores falls. About 150 gallons per acre is usually found necessary for each application. More than 200 gallons should not be required. The cost is not large. European experience gives about 7 or 8 shillings per acre as an average for each application. Many prefer to use a mixture of twice the strength of that above. As many as six light sprayings are sometimes given in the United States at a cost of about 5*s.* per application. Sulphate of copper costs about 3*d.* to 4½*d.* per lb. in Europe. A Calcutta firm informs me that it can be supplied in Calcutta at R20 per cwt, or less than 3 annas per lb.

Quantity required.

Cost.

61. In Darjeeling, Assam, and other districts of India where the rainfall is excessive, Bordeaux mixture may fail through being washed off the leaves. This appears to have occurred at the Upper Shillong Farm, Assam, where the treatment has not been a success. In such cases a method of increasing the adhesive properties of the mixture adopted with good results in other countries may prevent this undesirable event. This is the addition of treacle or molasses (about 5 lbs. in preparing fifty gallons as above), to the lime wash before adding it to the copper solution. The treacle should be diluted with some water so as to make it of a thin consistency.

A cause of failure.

Its prevention.

62. The use of this treatment renders the tubers in no way dangerous for consumption; for analyses, often repeated, show that none of the copper reaches the tubers. Sir Charles Cameron, Medical Officer of Health, for Dublin, found, however, that copper is taken up by the leaves and stems of sprayed plants though he also got no trace of it in the tubers.

Treatment safe.

63. The result of a thorough spraying is to coat the leaves and stems of the crop with a fine film containing the copper salts. On the spores falling into this their germination is prevented and infection of the plant does not occur. As may be seen this treatment is preventative not curative and it is usually considered that once the

Result of treatment.

* This is European experience. I believe that in India a simple syringe costing about a rupee would better suit the conditions of the cultivator to whom time and labour are of no particular account, while initial expenditure is.

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Experiments required in each district.

filaments of the fungus are growing vigorously within the substance of the leaves the mixture exercises little or no influence on their growth. Experiments are required in each district to determine the best means of securing the desired effect. The number of sprayings and the strength of the solution required depend to some extent on the climate, especially the rainfall.

Jensen's "protective moulding."

64. To prevent spores reaching the tubers by being washed into the soil, Jensen, of Copenhagen, instituted the system known as "protective moulding." His experiments indicated that the filtering effect of the soil in checking the passage of spores was considerable and he therefore recommended banking up the earth round the stems so that the uppermost tubers are covered with about 5 inches of soil. This should not be done until the disease usually is expected to appear, or at the first signs of it. By this means it is hoped that the spores will fail to penetrate to the tubers, The system has not found great favour, since experience goes to show that, though the number of diseased tubers is lessened, still the yield is smaller than in unbanked crops

Precautions in handling crop.

65. Some other precautions may be observed in handling the crop when disease occurs. The tubers should not be lifted for some time after the complete dying down of the stalks, or there will be a danger of infecting sound tubers by living spores from the leaves or soil. A less satisfactory way of avoiding late infection is by burning all débris on the ground. Some spores in the soil will, however, certainly escape the latter, and may convey the disease if the tubers are lifted immediately. At least a week should be allowed to elapse before stirring the soil, and in moist soils three weeks may be necessary, since, as already said, spores have been kept alive for this length of time. In storing tubers intended for seed the following season they should be kept in a dry well-aerated place. It has been found that spores are sometimes produced on the surface of diseased tubers in storage and these are readily conveyed to adjacent sound ones. The presence of moisture in these cases permits the spores to germinate, and the disease continues to spread from tuber to tuber.

Power of resistance to disease.

66. Besides the above treatments, all directed against the fungus, long experience has shown that there are other precautions quite as necessary in preserving the crop from disease. They may be summed up in the phrase "keep up the resistance to disease of the potato plant itself." For long it was believed possible to produce a disease-proof variety of potato. It is now, however, fairly evident that all varieties become liable in time, though some are less so than others. These latter, disease-resisting varieties, lose the property, if neglected, in a few years, and constant attention is required to keep them up to the standard by selection and by crossing with other

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varieties. This work, carried out by all the large nurserymen in Europe, is quite unknown in India. It is probable that the experience noted already of English potatoes in Darjeeling, and Naini Tal potatoes in Assam, having at first succeeded in withstanding the disease while afterwards succumbing, indicated the possession of this power to some extent; and it might have been possible by judicious selection, or by raising seed from the new varieties, to have established a strain resistant to a greater degree than the indigenous. Importing new varieties unless constantly practised cannot be expected to lead to any permanent diminution of the disease, but importation combined with selection may do so. The introduction of varieties grown from seed, not from tubers, from time to time, has been found essential in other parts of the world where disease prevails, since continued reproduction by sets tends to weaken the resisting powers of most plants. It is an undertaking that cannot be too strongly urged for India, where many of the native varieties are extremely poor, and the results of seed raising, with selection of the best plants only for future use, would probably give very rapid improvement.

Weakening of resistance.

Continued reproduction by sets.

67. The raising of two crops a year on the same land continuously is bound to give a weak crop unable to resist disease. It is not likely, however, to be abandoned. Besides being agriculturally unsound, it often leads to the first crop being raised when immature and thereby greatly increases the danger of late infection of the tubers.

Excessive cropping.

68. Excessive irrigation on badly drained land is also unwise. **Phytophthora** thrives best in moisture, and in moist soils the danger of the spores reaching the tubers is likely to be accentuated. An addition of lime to the fields may sometimes be useful. This is especially to be recommended where richly nitrogenous manures are employed. Nitrogen has been found to lower the resistance to disease somewhat, and this effect can be counteracted by the use of lime.

Excessive irrigation.

Addition of Lime.

69. It must be said that there is need of some accurate observations and experimental field work before European experience can be applied to Indian conditions with a maximum of success. It is possible that the excessive rainfall of some of the Hill districts, the great seasonable variations of temperature and moisture, and the difference in cultivation may lead to a modification of some of the methods found satisfactory in Europe. But the first requisite is a clear idea of the cause and mode of spreading of the disease, and of the conditions in which the fungus finds its greatest capacity for mischief, and these I have endeavoured to give. The knowledge thus acquired, intelligently used, should render possible the application of remedial measures to particular outbreaks with a fair prospect of success.

Need for observation and experiment.

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CHAPTER II.

"Bangle" blight.

First account of Bangle blight.

70. *History.*—A disease, known to the native cultivators by the name of "bangdi" disease, from the appearance of a dark ring visible on section in the substance of the potato, was brought to the notice of the Department of Land Records and Agriculture, Bombay, in 1891, (see "A Note on the Potato disease prevalent in the Poona district and elsewhere" by **E. L. Cappel**, Director of the Department of Land Records and Agriculture, Bombay, June 1892). It affected the crop of the Khed and Junnar Talukas, whence the greater part of the supply for the Poona and Bombay markets is drawn. Shortly afterwards it was reported to occur elsewhere in the Poona district, and in Gujarat and Mahableshwar. It was stated to have first appeared some three or four years earlier. By 1893 it had been found very widely distributed in India: at Bangalore, in the Nilgiris, in Bengal and all through Bombay Presidency. In the Nilgiris we have seen that **Phytophthora** disease has been long established. The occurrence of a second blight here does not seem to have been fully realised, and it is probable that no distinction is made between the ravages of the two pests. In Bengal Babu **Choudhury** found, while investigating the **Phytophthora** out-break, that the memory of a previous blight remained amongst the cultivators. It was spoken of as "Dhasa" a name also applied by some to the new disease. The two affections were, however, recognised as being distinct, and it is probable that the old Dhasa was "Bangle blight" which **Mr. Cappel** states extended to Bengal ("Second Note on the Potato disease prevalent in the Poona district and in other parts of India," 1893). It would seem to have now disappeared from that Presidency while still prevalent in Bombay. In the extent of its ravages it is probably second only to the **Phytophthora** in India.

Area affected.

Probably next to *Phytophthora* in destructiveness.

Dr. Cunningham's investigations.

71. In 1892 specimens of the disease were submitted by **Mr. Mollison**, then Superintendent of Government Farms, Bombay, to **Dr. Cunningham**, Special Assistant to the Sanitary Commissioner with the Government of India, a well-known authority on fungus diseases. His investigations were published in the Scientific Memoirs by Medical Officers of the Army of India, Part X, 1897. The leaves and upper part of the stalks were found by him to be normal, except in so much that they were wilted and showed a fading of the green colour. The base of the stalk, however, was discoloured, and in section brown spots were seen corresponding to the vascular bundles. On microscopic examination the vessels were found choked

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with the mycelium and minute sclerotia* of a fungus. The latter appeared to be strictly confined to the wood, being present in the interior of the spiral vessels, the wood cells and, especially, the great pitted ducts. It was in these ducts that the sclerotia were found. The upper part of the stem, the roots and the tubers were free from filaments of the parasite. Even the blackened area of the "ring" in the latter did not show its presence. In the following year further specimens were examined by **Dr. Cunningham**, and some modifications were found necessary in the above description. Thus the blackening of the stem was less marked, sclerotia were not found, and scattered filaments of a fungus permeated all the tissues, being still most abundant in the spiral vessels. **"BANGLE" BLIGHT.**

72. *Symptoms of the disease.*—The first symptom externally of the disease is a "wilting" of the green top, which occurs suddenly. A plant may look quite well one day, show signs of fading the next and droop on the third day. This does not occur generally throughout a field, but scattered plants everywhere are seen withering in the midst of green ones. The difference between this and the **Phytophthora** disease, which attacks field by field rather than plant by plant, is striking. The tuber is arrested in growth, so that the crop where disease is severe is generally poor and composed of small tubers; many are rotten when dug and others rot in quantity in storage. The disease appears only as the crop approaches maturity; and at first, even when the discolouration of the stalk just under the surface of the soil is apparent, the blackened ring is not visible in the tubers. Infection from plant to plant, so that the disease radiates from the first attacked plants, was not observed to occur to any great extent. The symptoms of the disease are considered by **Dr. Cunningham** to be due to obstruction of the free passage of water up the stem, by fungus filaments in the vessels. The disease is thus typically a "Wilt disease" of which many examples occur, both in India and elsewhere, amongst cultivated crops. **Rapid wilting.** **Not universal.** **Only appears at maturity.** **Tubers late affected.**

73. It does not appear that cultures of the fungus were obtained by **Dr. Cunningham**, and it remains doubtful, therefore, whether it is capable of dissemination by spores. Spores were not found in nature. **Dr. Cunningham** points out, however, that the characters of the disease and the nature of the fungus, especially the production of sclerotia within the vessels, are typical of certain Ascomycetous fungi such as **Sclerotinia (Peziza)** or its allies. In these the production of spores is not common, being in some species unknown, but the fungus persists from year to year by means of its sclerotia, **Spores not found.** **Dissemination by sclerotia.**

* Sclerotia are merely felted masses of the fungus threads which form bodies usually of a tough horny nature capable of preserving their vitality for a long time. They are not spores but are usually much larger bodies.

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which, like resting spores or the dormant mycelium of Phytophthora, can withstand variations of moisture and temperature, waking to life again when conditions become favourable.

Field work of the Bombay Department.

74. *Field experiments.*—In 1892 and 1893 extensive field experiments were carried out by the Department of Land Records and Agriculture, Bombay, for the purpose of testing the extent to which different varieties of potato suffer from the disease, and the means by which it might be combated. These did not bear out Dr. Cunningham's opinions in one respect, namely, that the fungus does not reach the tubers, since they pointed unmistakeably to seed infection as one of the ways in which the disease is propagated. Thus, although as a general rule, new potato land gave sounder crops than old, still in Khandesh, where potatoes were not previously grown, a field at the Government Farm which had never been under potatoes before, bore a diseased crop when sown with potatoes marked by the black "ring" of the disease. Infection from without was hardly likely here. "No conclusion has been more clearly pointed out by the experiments and observations conducted in the field during the past two years than that the disease is propagated from the seed as well as from the soil, and that if anything the first source of infection is the more dangerous and common" (Cappel, *l.c.*, 2nd note).

Seed infection occurs.

Predisposing causes.

75. Amongst the conclusions come to as a result of field experiments in Bombay were the following.

Over-cropping.

A predisposition to the pest is probably to be found as a result of exhaustion of the soil and of the stock, owing to overcultivation. "The crop is so profitable that it is grown year after year on the same land, and the unwillingness of the cultivator to exchange it for less valuable produce, even when disease is rife, forms one of the chief difficulties to be met. A rest from potato for three or four years would probably cleanse infected land" (Cappel, *l.c.*, 1st note). A saturated surface soil is favourable to the disease. On the other hand a trial of the ridge and furrow system to obviate this, did not prove as satisfactory for the crop, when compared with the bed system of the native cultivators, as was expected. Mr. Mollison suggests that the explanation of this is that the rapid assimilation of food which occurs under Indian conditions of climate is more easily effected where a superabundance of surface moisture is preserved. Such a crop he thinks may, however, have its resistance to disease lowered as a consequence of over-luxuriant growth. Different varieties of potato resist the disease to different degrees. Newly imported English and Kumaun seed gave good results, and the produce was eagerly bought for seed by the native cultivators. Infection probably occurs in two ways, through the seed, and through the soil. The sclerotia are certainly thrown into the soil from rotten stems and must infect it, for

Saturation of surface soil.

Comparison of bed and ridge planting.

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they are admirably adapted to preserve their vitality for long periods. They are probably to be found in the upper layers of the soil in infected lands.

Treatment by new seed.

76. *Treatment of the disease.*—The treatment suggested, and tried with considerable success, was based on these considerations. In order to avoid seed-infection new seed was imported, and, as already stated, escaped disease. As it was grown on land known to have borne diseased potatoes in previous years, this must have been due to a certain amount of inherent resistance to the disease. Since, however, this power appears to have been possessed by all of the imported varieties, it is, perhaps, more accurate to ascribe the difference in the behaviour of imported and indigenous seed to an abnormal weakness on the part of the latter brought about by unsound cultivation through many years. As in the case of **Phytophthora** disease, the immunity of imported varieties was lost after some years' cultivation. To be effective, in India, as in Europe, change of seed should be continuous. Indeed in India it would appear that deterioration is more rapid than in Europe, whether as a result of bad cultivation or of the climatic conditions I do not know. In view of the fact that by the native system of cultivation in beds, water used in irrigation surrounds the haulms at the seat of infection, namely, near the base, and must thereby assist the progress of the disease, the English ridge and furrow system was tried. Water for irrigation was run along the furrows, and naturally did not wash the base of the stalks. The sets were also planted wider apart than in the native system. The results of this mode of planting were rather contradictory. In some cases a greater outturn per acre was got. In others, where bed planting with the sets wide apart was employed, the results were better than in the ridge and furrow areas. The influence on the progress of the disease was masked by the fact that none of the newly imported seed used in the experiments was much affected. On the whole Mr. Mollison recommends growing on ridges. He considers that indigenous varieties, if planted in beds, are more subject to disease than if planted on ridges; while "as regards newly imported good varieties there can be no doubt that the ridge system of planting is best." ("*Text-book on Indian Agriculture*," Vol. III, 1901, page 204.) I have little doubt that flushing the stems on the native system promotes the entry of the parasite into the base and assists its growth when once it has gained the tissues. Finally, sulphate of copper, which had proved a failure when applied to the leaves, was added to the water used for irrigation in order to destroy the disease germs in the soil. The want of success in the earlier experiment was at once explained when the nature of the disease was pointed out by Dr. Cunningham. Sulphate of copper could have little effect on a

Immunity lost in a few years.

Deterioration of seed.

Ridge and furrow system.

Evil of flushing the stems.

Sulphate of copper.

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parasite which is firmly established in the interior of the stalk before it gives rise to external symptoms. On the other hand, the sclerotia, which Dr. Cunningham considers are the agents by which the soil is infected, are thrown free into the soil on the decomposition of haulms. In this state they can be easily reached by fungicides dissolved in the water used for flushing the fields. Eighty-four pounds of sulphate was used per acre, being added in concentrated solution to the water as it was raised from the well, a measured quantity to each bagful of water. This treatment was successful in diminishing the disease. It is, however, too expensive to be practicable on a large scale.

Soil treatment.

Burning the soil.

77. Mr. De Joss, Superintendent at Panchgani, found that burning the soil with vegetable débris, after well turning it up with the plough and exposing it to the sun, gave an alternative method of destroying the source of infection in the soil. He grew several varieties remarkably free from the disease in this manner.

Farm-yard manure after burning.

78. Where either of these methods of soil disinfection is practised plentiful manuring afterwards is to be recommended. The destruction of germs in the soil is a process not unattended with risk. In the treatment many organisms which are beneficial to plant life are destroyed; and recent research goes to show that the part played by these in assisting the growth of plants by providing them with easily assimilable food is very great. They may be, however, in part replaced by the use of farm-yard manure, which contains some of these organisms in considerable quantity.

Destruction of soil organisms.

Burning stalks.

79. One other precautionary measure may certainly be carried out with profit. This is the collecting and burning of all stalks from diseased fields, so as to avoid their rotting on the ground and liberating the internal sclerotia into the soil.

Diseases to which "Bangle" blight is allied.

80. *Diseases resembling "Bangle" blight.*—A number of diseases of potato, presenting resemblances to "Bangle" blight, have been described from time to time in other countries. They all possess the distinguishing character of attacking the stem rather than the leaves or roots. Frank ("*Kampfbuch gegen die Schädlinge unserer Feldfruchte*)" mentions four different fungi which have been associated with these diseases: **Verticillium albo-atrum** *Reinke*, **Fusarium pestis** *Sorauer*, **Rhizoctonia** *Solani Kühn* and **Botrytis cinerea** *Persoon.*

Sclerotial disease in Europe.

81. Of these four, the last, or a closely allied species, is believed to be responsible for a considerable amount of damage in Europe. A new potato disease appeared in 1880 in the west of Ireland. Mr. Worthington Smith who investigated it found a fungus attacking the stem, of quite a different nature to **Phytophthora**. In 1883 it was found in Scotland and Norway, and the fungus was named

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Peziza postuma by Berkeley and Wilson. De Bary considered it to be the same as **Sclerotinia (Peziza) sclerotiorum** *Lib.* The cases which have been described as due to **Botrytis cinerea,** in Germany and elsewhere, are probably also connected with this, since **Botrytis** is merely one of the stages of **Sclerotinia**. The disease is known in Ireland as "yellow blight," and has attracted a good deal of attention there. In its symptoms, especially in the wilting of the green top, and in its association with a fungus which forms sclerotia, it resembles "Bangle" blight. The sclerotia are, however, quite large and are formed externally, instead of within the tissues. The fungus extends from root to root through the soil, attacking many other plants as it meets with them. When the plant is lifted the white threads of the fungus are usually conspicuous on the outside of stem and roots. From these characters, it is probable that the Bombay disease is not identical with "yellow blight."

Different from "Bangle" blight.

82. It is also practically certain that the fungus of "Bangle" blight is not **Rhizoctonia Solani,** since the latter can be recognised by its filaments, which form characteristic enlargements.

Rhizoctonia Solani.

83. To endeavour to gain some further information regarding the cause of the disease I obtained specimens from Poona through **Mr. Mollison** in December 1902.

Further specimens obtained.

84. The tubers showed the characteristic brown "ring" in the interior on section and the stalks were discoloured and shrivelled as described by **Dr. Cunningham.** Within the tissues of some of the stems numerous threads of a fungus were found, chiefly in the vessels, which were crowded with them, but I could not find any sclerotia. The tubers as before showed none of these threads in or near the discoloured area, but in these, and in all the stalks, both those which contained fungus and those which did not, I found a condition which is significant in view of certain recent work on the stalk diseases of potato. A small bacillus was present in great quantity, principally in the vessels, but also in the surrounding cells, either scattered, or forming dense masses almost entirely filling the lumen of the cell. Cultures of this were obtained from both stems and tubers. On cubes cut out of the interior of the latter with a knife at a dull red heat and placed in sterilised flasks, drops of a whitish pus-like substance appeared after some days, exactly as described by **Tryon** in the Australian disease mentioned below. These drops consisted of myriads of the bacillus, which, however, differed somewhat from **Tryon's**, being only about twice as long as broad. As circumstances did not permit of further study of this organism, and no infection experiments were attempted, I do not wish to be taken as suggesting that we have here, rather than in the fungus studied by **Dr. Cunningham,** the true cause of disease. It has, however, recently

Characters of diseased tubers.

Fungus in the vessels.

Bacteria also found.

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Parts played by fungi and bacteria, respectively, in certain diseases.

Bacterial disease in America and Australia.

In Europe.

Possibility of bacteria being concerned in "Bangle" blight.

been found that the part played by fungi in the stem diseases of potato has been exaggerated; and that several of the diseases supposed to have been caused by the fungi enumerated above, are really due chiefly to bacteria. Thus Frank, while stating that these fungi are often found together with the bacillus, established by experiment that the latter alone is quite capable of producing the disease. Smith, in America, and Tryon, in Australia, found that the greater part of the damage in these two countries is due to one and the same organism, the **Bacillus Solanacearum** *Smith*. Prillieux and Delacroix, in France, and Kramer, in Germany, have similarly described bacterial diseases closely resembling "Bangle" blight and sometimes accompanied by a fungus, not in itself capable of causing much harm. It may be said that a bacillary stem disease of potatoes, resulting in the wilting of the green top, is one of the few bacterial diseases of plants established beyond reasonable doubt. If it be eventually shown that "Bangle" blight is of this nature, the fact of seed infection, brought out by experimental cultivation in Bombay, will be explained. For though the fungus is not to be found in the tubers, the bacillus is, and can doubtless pass to the new shoots when they appear.

Farukhabad diseases.

Cultivation in Farukhabad.

"Bangle" blight in Farukhabad.

85. In the end of December 1902 Babu Rameshwar Dayal of my office obtained some specimens of a disease which was damaging the crop at Farukhabad. Two diseases are distinguished by the cultivators in this locality. One called "agia" (from *ág*-fire), is said to be endemic, but appears to attack the potatoes known locally as "Desi" only. It will be returned to below under the head of "Early blight." The other, called "pálá" (frost) was doing much damage to "Madrasi" potatoes, and was said to occur in any year when there is but little moisture in the soil.* The seed is sown in September and October and harvested in December to February. The fields receive indigo seed, castor cake and night-soil as manure, and are irrigated from ten to fifteen times. The disease is marked by a withering of leaves and stalks, and a stunting of the growth of the plant. Seed tubers of the "Madrasi" variety and complete plants in all stages of "pálá" were sent to me, and examination showed that all the characters of "Bangle" blight were present in some of them. The seed was marked by a well-defined brown ring on section and the stalks were discoloured and wilted. Fungus hyphæ occupied the vessels near the base of the stalk, and bacteria, resembling

* Further information and specimens received through the Department of Land Records and Agriculture, United Provinces, in January 1903, made it probable that the cultivators confuse under the name of pálá, "Early blight," "Bangle" blight, and the effects of frost, all of which caused some damage in Farukhabad this year, though nothing, so far as I could ascertain, in any way serious.

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those of the Poona disease, were found both in stalks and tubers. The latter were cultivated and gave the same white drops consisting of masses of a short rod-shaped bacillus as above described. Pálá is evidently in part nothing more or less than "Bangle" blight.

"BANGLE" BLIGHT.

86. Babu Rameshwar Dayal was informed that the yield was only about half of the normal in attacked fields. Tubers of diseased plants are very small, and are preserved for next year's seed. It is not to be wondered at that the disease is endemic, and that the outturn is extremely poor in the attacked fields. The marvel would be if the produce of such seed gave anything approaching to a good potato. Apart from bad seed the cultivation of the district is high.

Loss in Farukhabad. Use of diseased tubers for seed.

87. I do not, for a moment, believe that these few instances exhaust the localities in which "Bangle" blight exists. Information is hard to get on such points, but it is probable that the disease is not restricted to a few provinces, but is widespread throughout the country.

Probable that "Bangle" blight occurs elsewhere.

OTHER POTATO DISEASES.

CHAPTER III.

Other Potato Diseases in India.

Pythium disease.

88. In the same paper in which "Bangle" blight was described, Dr. Cunningham gives an account of three other diseases of potatoes. The first of these he calls "Root-blight caused by the invasion of the tissues by a species of **Pythium**." This was found in the plains of Northern India at Saharanpur, Gurdaspur and Batala, in the Gurdaspur district, in 1893. There was no sign of **Phytophthora** on the leaves or stalks. Furthermore the tubers were perfectly healthy in appearance, with the exception that in some red-skinned specimens there was a narrow zone of bright pink in an area corresponding to that in which the fibro-vascular bundles are distributed, dependent on the presence of a certain number of cells containing a red colouring matter, like that found in the cortical tissues. In the base of the stem and the larger roots a fungus of the genus **Pythium** was found in the cellular tissues and also to a less extent in the fibro-vascular bundles. This genus is allied to **Phytophthora**, but the members of it are much less strongly developed parasites, being in fact in many cases entirely without the power of attacking living plants. The fungus occurred only in the subterranean parts of the plant, but here its threads and spores were abundant within the tissues. The threads of **Pythium** closely resemble those of **Phytophthora**. They have, however, the power of boring their way directly into the cells and not alone between them. The result is usually to set up a moist rot, which, as in the case of **Phytophthora**, is partly the work of bacteria following the fungus. A rot of this sort, starting at the base, usually has, as its result, a total collapse of the plant while the top is still green. The stalk itself remains soft and does not dry up as in "Bangle" blight. The spores in this disease were formed within the tissues, and were of two sorts. One resembled those already described for **Phytophthora**, except that instead of being produced on tree-like branches rising into the air, they were formed singly at the extremity of short stalks within the roots and under-ground portion of the stem. Their germination was not observed but was presumably like that of the other species of **Pythium**, either by means of zoospores or of a germ-filament, in other words very much like that of **Phytophthora**. In **Pythium vexans** *de Bary*, which is in many respects extremely like this fungus, though not known as a parasite, germination by zoospores is rare. The other form of spore found, was a sexually-produced oospore with a thick wall, and probably, like the oospores of allied species, well suited to surviving for long intervals

Characters of *Pythium*.

Characters of *Pythium* rot.

Spores.

Sexual or resting spores.

OTHER POTATO DISEASES.

of time in a dormant condition. These oospores were produced in large quantity, and must have been set free copiously into the soil from the rotting haulms and roots. There they would lie until, perhaps, a new crop was planted, when if provided with sufficient moisture, as by irrigation, they would germinate and reproduce the disease. They germinated freely after a short resting period, when placed in water, giving rise to a branched germ-tube which grew to form a new generation of the fungus.

Reproduction by resting spores.

89. Dr. Cunningham did not identify this **Pythium** so as to name it specifically. **Pythium** has been described as the cause of potato blights on more than one occasion. De Bary has shown that **Pythium de Baryanum** *Hesse*, can attack potatoes vigorously. Sadebeck also found a species which appeared to do severe damage near Coblenz. He named the fungus **Pythium Equiseti**, but it is scarcely possible to distinguish it by his description from **Pythium de Baryanum** and it was probably in reality this fungus. From Dr. Cunningham's figures it is quite clear that his species was not **Pythium de Baryanum**, since it differs in a character which is usually considered one of the most important for distinguishing the various species of **Pythium.** This is the size of the oospore and the relative proportion it bears to the cell in which it is formed, or "oogone." In **Pythium de Baryanum**, the oospore entirely fills the oogone, whilst in Dr. Cunningham's species, the figures clearly show that the oogone is much larger than the oospore. I have had an opportunity of examining most of the known species of **Pythium**, and of those I have seen **Pythium vexans** *de Bary* most nearly approaches the figures of Dr. Cunningham. But **Pythium vexans** is not known as a parasite, and de Bary failed to make it attack living plants. It must, therefore, remain a matter of doubt whether the fungus has been described before or not. It is also, as Dr. Cunningham points out, by no means proved that it has anything to say to the disease at all. Since, however, no other cause was found, Dr. Cunningham's recommendations for treatment were based on the assumption that the blight is essentially dependent on the presence of the **Pythium.**

Previous references to *Pythium* diseases of potatoes.

Connection with the disease not proved.

90. *Treatment of the disease.*—The measures suggested by him were, in the first place, the avoidance of all excessive irrigation, and in the second, the careful removal and destruction by burning of all portions of blighted haulms and roots. **Pythium**, like **Phytophthora**, revels in moisture, the more so that it is capable of living in the soil, external to its host plant. There is, in fact, no limit to its existence as a saprophyte (*i.e.*, gaining its nutrition from dead organic matter) whereas **Phytophthora** dies rapidly if not provided with living food in the shape of the potato or one or other of some half-dozen plants. In a saturated soil the reproduction by swimming

Avoidance of excessive irrigation.

Burning of diseased parts,

OTHER POTATO DISEASES.

spores is greatly favoured, while a dry one largely diminishes the possibility of spreading by this means. Again, since resting-spores are formed within the plant tissues, and these can persist from year to year, the destruction as completely as possible of all débris on the fields is clearly indicated. The same result would be attained still more completely were a strict rotation adhered to, so that the crop should not occupy the same field two years in succession. Rotation, however, though so carefully practised with regard to many other crops in India, appears to be a counsel of perfection where potatoes are concerned.

Rotation the best remedy.

91. The next blight mentioned in Dr. Cunningham's paper, is known as "Karrah" by the natives of Oudh, where it has caused considerable damage in the neighbourhood of Lucknow. This is a leaf disease, and associated with it two fungi were found. The tissues of the leaves were everywhere permeated by fungus hyphæ, which gave rise to two different forms of spores. The first, and by far the most abundant, of these, consisted of erect unbranched filaments, capped by clusters of large colourless uniseptate spores. These germinated directly in a few instances, but usually each chamber of the spore formed a definite wall within itself, so that it came to contain lying free within it a single nearly circular spore—"as if each of the loculi of the original conidioid bodies became converted into a unisporic sporangium ere germination took place." The second form of fructification presented the characters of **Fusisporium Solani** *Mart.* This, however, was clearly saprophytic, living only on the dead tissues of the leaf and therefore having nothing to do with the cause of the disease. This may have been the case with the other also, and Dr. Cunningham concludes that it would be impossible, without further enquiry, conducted locally, to determine the true nature of the blight.

"Karrah" blight in Oudh.

A leaf disease.

Two fungi found.

True nature of the disease not known.

92. Another disease was found by Dr. Cunningham in samples of potato tubers received from Poona in 1894. It was due to a fungus whose mycelium penetrated the tubers, and after exhausting their nutritive substances produced an abundance of ovoid sclerotia of a fairly large size. Externally they appeared sound enough, though a little soft, while on cutting them open large irregular cavities were found, lined with a thick coating of white mycelium. The tissues surrounding these cavities were softened, and in advanced cases the whole of the interior was reduced to a pulp. In this the sclerotia were found in large numbers. Experiments were made with this fungus to ascertain its infective power as a parasite. On the leaves of **Ficus stipulata** and **Begonias** a spreading blight was produced by it, the surface of the leaves becoming covered with the filaments which penetrated into the interior through the stomata. On intact potatoes, however, it failed to effect an entry across the thick rind, though

Sclerotial disease of tubers from Poona.

Experiments of Dr. Cunningham.

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growing on the surface of the latter freely in a moist atmosphere. When the continuity of the rind was broken by a wound, the raw surface was soon covered with a dense fleece of mycelium while the tissues beneath became disorganised. In these cases, eventually, all the phenomena of advanced disease were reproduced. In the specimens received from Poona the active agent in providing the fungus with a mode of entry was a species of acarus or mite. It was this which formed the irregular cavities above mentioned, and the same pest had been previously found, unaccompanied by any fungus, in specimens from Jullundur received in 1892. The mites alone were capable of causing destruction of the tubers, but the progress of destruction was much more rapid when they found themselves accompanied, as in the Poona samples, by a fungus possessed of definite parasitic properties.

OTHER POTATO DISEASES.

Proof that the fungus causes the disease.

A wound parasite.

Wounds caused by a mite.

93. *Treatment of the disease.*—For treatment Dr. Cunningham recommended keeping the tubers as dry as possible, and burning all those which showed any signs of the disease. The first of these measures will tend to repress the multiplication of both acarine and fungal elements, and the second will ensure the destruction of acari, ova and sclerotia, and prevent the reproduction of both of the causes of the disease.

Keep dry.

Burn all diseased tubers.

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Figure 7.—**Alternaria Solani** *Sorauer.*—A shoot showing the characteristic appearance of "Early blight" (after Galloway).

94. A disease, identical with that known in America by the name of "Early blight," has quite recently been brought to my notice from Farukhabad. It is that which has been referred to on an earlier page as known to the cultivators, in the vernacular, as "Agia." Specimens and local information regarding it were obtained for me through

"Early blight" in Farukhabad

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SOLANUM tuberosum. | **Potato Diseases of India.**

OTHER POTATO DISEASES. **Cause.** **A leaf disease.** **Diagnosis.** **Attacks the young crop.** **Progresses slowly.** **Cause of death.**

the Department of Land Records and Agriculture, United Provinces. A few fields only were diseased this year (1902-1903), and even in them the damage was not considerable. "Early blight" is caused by a fungus, **Alternaria Solani** *Sorauer* (**Macrosporium Solani** *E. & M.*) which, like **Phytophthora**, attacks the leaves. It can be easily distinguished from **Phytophthora,** however, especially in the earlier stages. Figure 7 shows the characteristic appearance of circumscribed brown spots which grow at the circumference, and are usually marked by concentric rings indicating the stages of growth. It is, as the name implies, a disease of early appearance, thus contrasting with "Bangle" blight which does little harm until the crop is approaching maturity. Progress is slow as compared with **Phytophthora**, and the leaf may live for a week or more. Eventually it withers, turning a light brown, not blackish as in **Phytophthora** disease. In a bad case all the young leaves are attacked and the plant dies from lack of nutrition. Figures 8 and 9 show the peculiar spores, characteristic of **Alternaria,** by which the disease is spread. Treatment is chiefly by Bordeaux mixture in America, where alone the disease is severe. In India, there is no indication at present of its becoming a dangerous pest, though I have on many occasions found in hastening the destruction wrought by **Phytophthora**. Bordeaux mixture would offer the best prospect of success should the treatment ever become imperative. Short of that, since **Alternaria** is a "weak parasite," *i.e.*, one unable to produce much injury, except where the vitality of the plant is diminished from some other cause, high cultivation is the one means clearly indicated of lessening the liability to attack.

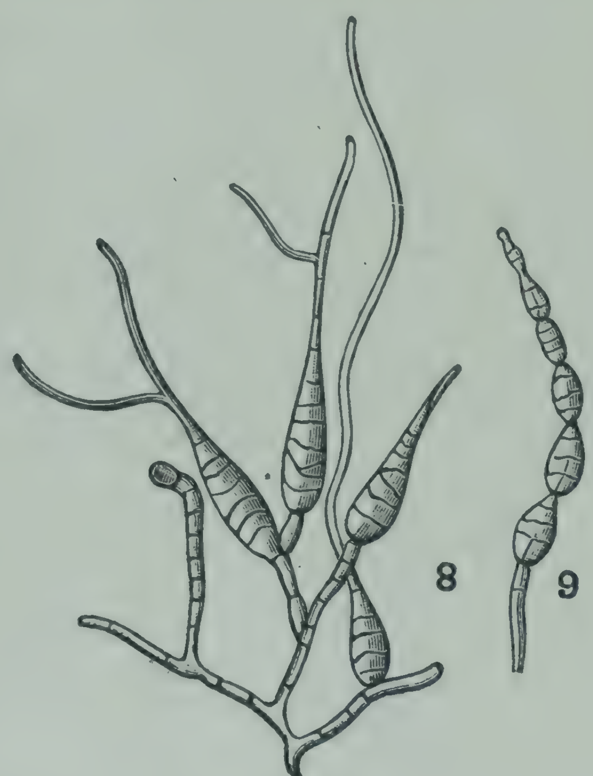

Figure 8.—**Alternaria Solani** *Sorauer.*—Spores from a diseased leaf (after Sorauer).
Figure 9.—Chain of spores of **Alternaria Solani** (after Sorauer).

Treatment by Bordeaux mixture. **Not dangerous at present in India.** ***Alternaria solani* a weak parasite.**

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PULSES OF INDIA.

(ASSAM VALLEY PULSES.)

[*Dictionary of Economic Products, Vol. VI., Pt. I.,* P. 1410-25.]

Other DICTIONARY articles that may be consulted:

Cajanus indicus, *Vol. II.*, C. 49-57.
Dolichos biflorus, *Vol. III.*, D. 758-88.
Glycine hispida, *Vol. III.*, G. 263-70.
Lathyrus sativus, *Vol. IV.*, L. 100-9.
Lens esculenta, *Vol. IV.*, L. 252-65.
Phaseolus Mungo, *Vol. VI., Pt. I.*, P. 496-522.
Pisum arvense, *Vol. VI., Pt. I.*, P. 882-4.

THE CULTIVATION OF PULSE CROPS IN THE ASSAM VALLEY.

By MR. B. C. BASU, *Assistant to the Director, Department of Land Records and Agriculture, Assam.*

Kinds of Pulse Grown.

Assam sorts of pulse cultivated.

The following kinds of pulse are grown in the Assam Valley, named in order of importance :—

(1) *Máti-máh* (Phaseolus Mungo *var.* radiatus).
(2) *Magu-máh* (P. Mungo).
(3) *Kalá-máh* or *khesari* (Lathyrus sativus).
(4) Lentil or *masur-máh* (Lens esculenta, *syn.* Ervum Lens).
(5) Peas or *matar-máh* (Pisum arvense).
(6) Horse gram or *kulthi-máh* (Dolichos biflorus).
(7) *Rahar-máh* (Cajanus indicus).
(8) *Bejia-máh* (Pueraria phaseoloides).
(9) Soy-bean or *pátani jokrá* (Glycine hispida, *syn.* G. Soja).

Besides the foregoing, the ripe seeds of several species of creeper bean, such as the Indian butter bean (Dolichos Lablab, Ass.

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PULSES. **The Cultivation of Pulse Crops**

FIELD PULSES.

urahi), the Asparagus bean (**Vigna Catjang,** Ass. *lecherá-máh*), and the Lima bean or *katári-dabuá-máh* (**Phaseolus lunatus**), are occasionally used as pulse or *dál,* but since these beans are grown as garden crops mainly for use as vegetables, it is not proposed to deal with their cultivation here. A description of field pulses alone is attempted in this note.

Among the pulses grown in the Assam Valley *máti-máh** occupies the foremost place. It forms one of the staple crops of the province, ranking in importance next to rice and mustard, if we except tea which is outside the scope of ordinary cultivation. The special crop statistics do not show separately the areas annually cropped with different pulses, but it can be safely said that not less than 90 per cent. of the total area so cropped is occupied by *máti-máh* alone. The following were the aggregate areas in 1901-1902 occupied by all kinds of pulse in the five upper districts of the Assam Valley, for which we possess complete statistics :—

Area under cultivation.

District.	Total cropped area, excluding tea and coffee.	Total area under all pulses.	Percentage of col. (3) on col. (2).
1	2	3	4
	Acres.	Acres.	
Kamrup	489,151	20,173	4·1
Nowgong	203,592	16,377	8·0
Darrang	247,024	11,853	4·8
Sibsagar	423,137	15,985	3·8
Lakhimpur	171,047	5,832	3·4
TOTAL .	1,533,951	70,220	4·6

The cultivation of pulses reaches its maximum in Nowgong, where these are extensively grown in the large *chapari* tract lying between the Kalang and the Brahmaputra. The bulk of the area cropped with pulses is found in the flooded alluvial flats bordering on the Brahmaputra river and on its principal tributaries. In the higher-lying permanently cultivated tracts, pulses are grown more or less in almost every village, but the crops are generally poor. Further inland, along the foot of the hill ranges, the country is inhabited by Kacharis, Mikirs, and other non-Hindu tribes, for whom pulses do not possess much attraction, and by whom they are little grown.

* *Máh* is the generic name for all kinds of pulse. The word is derived from Sanskrit *máshá,* after which the Indian jeweller's weight *máshá* is named.

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MÁTI-MÁH.

(Phaseolus Mungo, *Linn. var.* radiatus, *Linn.*)

Bengali—*Máshkalái.*
Hindi—*Urd.*

PHASEOLUS MUNGO var. RADIATUS.

Varieties.

Varieties.—There are two well-recognised varieties of this pulse. The ordinary kind or *máti-máh* proper, also known as *kali-máh*, has black seeds, and a second variety known as *kapau-máh* কপৌমাহ (other names are *ráng-dengiá-máh* and *deuri-máh*) has yellowish green seeds, a little larger than those of the former. The latter variety seems to be an intermediate form between *máti* and *magu máh ;* the leaves are of a lighter colour, and the pods lack the central dark stripe, which characterises the black variety ; the grain is also considered better eating than the black kind. A sub-variety of *kali-máh* is known as *chungi-máh*, which is distinguished by the pods being turned upwards and the close compact growth of the plant unlike the spreading habit of the ordinary form of the *kali* variety, which is also known as *latá máti-máh.* The different kinds are ordinarily grown together, the cultivators showing no preference for any particular kind ; but *kapau-máh* is sometimes grown singly. The rains variety of *urd*, which is grown in Bengal and the United Provinces of Agra and Oudh is not known in Assam, the climate being perhaps too wet to allow it to come to maturity.

Distribution. Soil.

Distribution and kind of Land and Soil on which it is ordinarily grown.—As stated above, *máti-máh* is grown more or less in every part of the Assam Valley, but it is principally cultivated in the loamy alluvial tracts or *chaparis*, as they are called, on both banks of the Brahmaputra river and its main tributaries. For *máti-máh* the most productive lands are naturally those which annually receive a deposit of silt or are newly reclaimed from forest. It is, however, absolutely necessary that the land should get sufficiently dry by the end of September, which is considered the latest date for sowing the crop. In the higher country removed from the influence of the annual floods, *máti-máh* is ordinarily grown as a second crop after rice seedlings and early rice, and also in fields that have borne a sugar-cane crop in the previous year. Rice seedlings (*kathiá*) like sugar-cane (*gánthiá*) and the *áthiá* plantain are believed to be exhausting crops, the three being named together in the pithy saying—" আঠীয়া কঠীয়া গাঠীয়া " (*áthiá kathiá gánthiá*). The succeeding pulse crop is never expected to give a good yield, but intelligent cultivators believe in its ability to improve the fertility of the soil ; this belief may have influenced the custom of taking a pulse crop after sugar-cane and rice seedlings. Loamy soils are considered

PULSES. | **The Cultivation of Pulse Crops**

PHASEOLUS MUNGO var. RADIATUS.

the best for *máti-máh*, and of such soils there is no lack on the extensive *chaparis* abutting on the Brahmaputra river.

Alternative crops.

Rotation.—There is no well-recognised system of rotation followed in regard to this pulse, but on lands which are annually cropped with rice seedlings (*kathiá tolí*), *máti-máh* is commonly taken as a secondary crop year after year. In *chapari* lands, which are abandoned after two or three years of cultivation, *máti-máh* is taken if the land gets dry in time as first or the last crop in the well-known rotation under which *áhu* and mustard are grown. In convenient situations it may be grown for one or more years after the rotation proper has ceased. In land covered in the natural state with *ulu* grass, the usual thing is to break it up in August and September, and take *máti-máh* as the first crop before commencing the rotation of *áhu* and mustard.

Cultivation.

Cultivation.—The cultivation of this pulse is of the scantiest description as is well indicated by the country proverb :—

" মাহে কয় পার যদি চহাবি
নোৱাৰো যদি ঘঁহাবি "

i.e., says *máh*—plough if you can, if not, scratch.

Two ploughings are the usual rule, but in hard soil, as many as four may be required. The land is left in lumps and never harrowed. Too much cultivation and a fine tilth are apt to encourage excessive growth of foliage at the cost of the yield of grain. This fact indicates, I think, the poverty of the Assam soil in some of the mineral ingredients of plant food, probably potash and phosphoric acid, which are necessary for seed formation. In *chaparis*, if it be intended to take pulse as the first crop of the rotation, the land has to be cleared of grass or reed jungle before it can be ploughed. It is not an uncommon practice to scatter *máti-máh* broadcast among rice stubble, or even among standing *sáli* rice when the soil is still somewhat soft, in the same way as *khesári* is ordinarily sown. This method of cultivation obtains chiefly in Nowgong, Kamrup, and Mangaldai, but not to any great extent. It is resorted to only when the rice crop fails. A more common practice is to sow *máti-máh* broadcast on the soft silt left by the floods, if the land is found to be free from jungle. In such cases, no cultivation whatsoever is necessary. Manuring is considered wholly unnecessary for this crop. The people, on the other hand, rightly believe in its power of improving the condition of the land, and on poor exhausted lands they grow it as much for this sake as for the sake of its produce.

Sowing season.

Sowing.—The season for sowing *máti-máh* may be said roughly to coincide with the month of September (from 15th *Bhádra* to 15th

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Áswin); in high village lands the sowing must be finished by the middle of September; in *chaparis* the season may extend to the middle of October, but late-sown crops do not seed well. The best time for sowing is said to be the last four days of *Bhádra* and the first four days of *Aswin*, as inculcated in the proverb, which runs as follows:—

ভাদৰ চাৰি আহিনৰ চাৰি।
মাহ বোবা যিমান পাৰি॥

and translates thus:—Sow *máh* as much as you can during (the last) four days of *Bhádra* and (the first) four days of *Áswin*.* The quantity of seed sown varies from 6 to 9 seers per acre, according as the sowing is early or late. Thick sowing is discountenanced, as it prevents the plants which come up thickly from spreading and attaining proper growth. The necessity for thin seeding is indicated in the following proverb:—

"ঘন সৰিহ পাতল মাহ।
মগুৰ তলত চৰে হাঁহ॥"

i.e., mustard should be sown thick; *máh* thin; ducks (should be able to) graze under *magu*. The seed is scattered broadcast and harrowed into the soil. On high village lands *máti-máh* is always grown as a single crop, and such is also the case in *chaparis* in Upper Assam; in Lower Assam it is occasionally mixed with *khesári* and peas.

Season of harvesting.

Harvesting.—The crop receives no other treatment before harvesting. It remains on the ground for about four months. In the drier village lands, it comes to maturity earliest, and seldom remains on the ground longer than three months and a half; in *chapari* lands, where the soil is more moist, the plant remains green longer and takes almost four months and a half to mature properly. *Máti-máh* is not much liable to shed in the field, and is gathered in at leisure. The harvesting season extends from the end of November to the middle of February, but the bulk of the crop is got in by the first half of January. The plants are simply pulled up by the roots and left to dry in the field from a week to a fortnight according to the state of the weather and the convenience of the cultivator. They are then collected into bundles and brought into the threshing floor. The threshing is ordinarily done by cattle in the same way as for paddy. *Máti-máh* is rather difficult to thresh, as the grains do not separate readily from the pods. To expedite the threshing, a man goes on beating the mass on the floor with a stick all the time the

* Another and more plausible interpretation of the proverb is—"Sow *máh* during *Bhádra* and *Áswin* after excluding the first four days of the former and the last four days of the latter".

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PULSES. The Cultivation of Pulse Crops

PHASEOLUS MUNGO var. RADIATUS.

cattle are going round—an operation which has given rise to the following saying:—

" মাহর মার দেখি তিলে বেত মেলে।"

i.e., the sesamum opens its lips on seeing how *máh* is beaten. After threshing, the grain is winnowed and freed from chaff in the ordinary way.

Weather. Diseases. Injuries.

Weather, Diseases and Injuries.—Light rain during growth is considered beneficial, but the crop is injured by rain at blossoming time, after which the weather should be quite dry. Heavy rain immediately after sowing causes the seed to rot in the ground and is injurious to the crop at every stage. In *chapari* tracts if the flood is late in subsiding, the area available for pulse-sowing is necessarily curtailed.

The *máti-máh* crop is liable to several kinds of insect pests:—A nocturnal caterpillar known in Upper Assam as *surpoká* does much injury by cutting down the stems. It is probably the caterpillar of a Noctues moth allied to the species which injures seedlings of cabbage, brinjal and other garden crops. A plague of caterpillars, which the people speak of as *bichhábán* (বিছাবান), appeared in 1900 in North Kamrup and ate up almost the entire crop of pulse, and caused much mischief also to mustard, tobacco and garden crops. On old exhausted village lands, and occasionally on *chapari* lands also, *máti-máh* suffers from a disease locally known as *khár-uthá* (খারউঠা) (literally Alkali-rising), also called *kháre-dhará*, small patches here and there drying up in the midst of a thriving crop. Heavy rain or excessive dampness of soil is the cause of this disease. The crop is also infested with a red mildew called *rangoli* (also known as *rangá-pará*, *chilá-rog* or *swarag-pará*), but it does little harm. This last disease also affects rice and other crops.

Yield.

Outturn.—The average* of 2,133 crop cuttings made with this crop extending over a period of 16 years gives an outturn per acre of 467 lbs., or about 6 maunds of pulse. The real average may not be far removed from this figure. On the rich annually fertilised *chapari* lands, very good yields rising as high as 12 maunds per acre can be obtained, but on the poorer and impoverished village lands, the yield is generally very poor, and an outturn of 3 maunds to the acre would be considered a good crop.

Storing.

Storage.—There is no special way of storing the pulse when required for food, but seed pulse is usually kept in what are called *topás* or *tomes* made of thin bamboo slips woven in a roughly globular shape. These are inlaid with straw and plastered outside with a

*The average is for the whole province, but the great majority of the experiments were made in the five districts of Assam proper.

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mixture of cowdung and mud with a view to keep out damp and insects. This method of preserving seed is common to every kind of food-grain grown in the Assam Valley.

Trade.

Trade and Prices.—There is no export trade in any kind of pulse grown in the Assam Valley, the local production being insufficient for the requirements of the people. A large proportion of the population is composed of foreigners, who are great consumers of *dál,* and for whom a large quantity of pulse of different sorts has to be annually imported from outside the province. The total quantity of pulse imported into the Brahmaputra Valley in 1901-1902 was 273,559 maunds = 9,192 tons.

There is very little internal trade in *máti-máh* or any other pulse within the province, as the bulk of the crop is consumed where it is grown. There is some export trade in pulse from the Nowgong and Sibsagar *chaparis* to Gauhati, but in the absence of internal trade registration, I cannot say what the volume of this trade may be.

Uses.

Use.—The main use to which this pulse is put is of course as *dál,* which is prepared in various ways. It is also used by Hindus as an offering to the gods, for which purpose the grain is steeped in water for a night and then washed to remove the husk. In this state it is called *prashad,* which is eaten uncooked with salt and ginger. *Máti-máh* is also in great demand from cartmen as food for their bullocks. It is also sometimes given to milch cows, but the practice is by no means general in this province.

MÁGU-MÁH.

Phaseolus Mungo, *Linn.*

PHASEOLUS MUNGO.

English name—The mung pulse.

Hindi—*Mung.*

Bengali and Lower Assam—*Mug.*

Botanically speaking, *magu-máh* and *máti-máh* are mere varieties of one and the same species. The main points of difference between the two consist in the leaves of *máti-máh* being darker coloured and these, as well as the pods, being more pubescent than those of *magu-máh. Magu-máh* is a more delicate plant, and its grain is more tasty than *máti-máh* and is consequently more highly prized.

Varieties.—Two varieties of *magu-máh* are grown in Assam:

(1) *Assamese magu,* also called *kali-magu,* having small dark greenish seeds, and (2) *Bengali magu* (also called *soná mukhi, bagi,* or *kapau magu*), having larger and greenish yellow seeds. The latter variety resembles the well-known *soná-mug* of Bengal, but the colour is not so bright yellow as in the true Bengal variety.

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PHASEOLUS MUNGO.

Among pulses, *magu-máh* is most esteemed, being considered more wholesome than any other pulse, and also for the sake of its fine flavour.

Distribution.

Distribution.—In Assam its cultivation ranks next in importance to *máti-máh*. It demands more care than the latter. The crop is chiefly grown in the flooded alluvial country bordering on the Brahmaputra, and seldom on old impoverished village lands such as are ordinarily cropped with *máti-máh*.

Cultivation.

Cultivation.—The land requires a better tilth and should be ploughed and harrowed oftener than in the case of *máti-máh*. The quantity of seeds sown is somewhat less than in the case of *máti-máh* and may be roughly put at 6 seers per acre. The crop matures a week or 10 days earlier than *máti-máh* and is easier to thresh. In all other respects the two pulses differ but little from one another.

Outturn. Price.

Yield and Price.—The outturn is somewhat smaller, but it is more than made up by the higher prices it commands in the market. The price usually varies from R3 to R5 per maund.

Injuries.

Injuries.—Unlike *máti-máh*, *magu* is subject to injury in store by a species of moth, which also infests several other kinds of pulse.

Uses.

Uses.—The uses of *magu* are very much the same as those of *máti-máh*, except that it is too valuable to be fed to cattle. Being delicate and easily cooked, it requires no *khár* or alkali in cooking as in the case of *máti-máh*.

KALÁ-MÁH.

LATHYRUS SATIVUS.

Lathyrus sativus, *Linn.*

English name—Garosse, Gesse.

Bengali and Hindi—*Khesari*.

Lower Assam—*Kalá*.

Variety.—Only one variety of this pulse is known in Assam.

Distribution. Soil.

Distribution and Soil.—*Kalá* is grown chiefly in Kamrup and Nowgong and the western parts of the Darrang district. In Sibsagar, it is still looked upon as a novelty, its cultivation being practically confined there to the Majuli and to the heavily-flooded mauzas on the south bank of the Brahmaputra river. There are two well-recognised methods of growing this crop. In the first method the crop is grown on low paddy land, the seed being scattered broadcast on the soft muddy soil among the paddy bushes. The second method obtains in the *chapari* tracts, where the land is prepared in the same way as for mustard and other cold weather crops. *Kalá-máh* does best, when sown among *sáli* or *báo* paddy on clay soils such as would

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retain moisture through the cold weather. In *chapari* lands the soil is ordinarily of a loamy description, and as a sufficient store of moisture is left in the soil by the annual floods, the crop is seldom liable to suffer from drought. Self sown crops of *kalá,* as well as of peas and lentil, are occasionally met with. They continue to crop up for years in situations where the soil is favourable. If the crop is promising, it is looked after and harvested, but, as a rule, such crops are too poor to receive any attention.

Rotatory and mixed crops.

Rotation and Mixtures.—When sown in low lands *kalá* should be regarded as a catch crop after winter rice (*sáli* and *báo*), as the land requires no additional cultivation. In *chapari* lands, *kalá* is taken as an alternative for mustard in the well-known system of rotation, under which *áhu* is followed by mustard year after year. It then forms the last crop of the rotation. A little peas is always found mixed with *kalá* in the field ; the two pulses are sown and reaped together, and the cultivators do not think it necessary to separate them. *Kalá* is also sown in mixture with mustard, and on rare occasions with *máti-máh.*

Cultivation.

Cultivation. —As previously said, no cultivation whatsoever is necessary when the crop is sown among standing low-land paddy. The same is the case in *chapari* lands when the flood has left a thick deposit of silt and killed the jungle. The general custom, however, in the *chapari* tracts is to give the land from four to six ploughings and three or four harrowings until a sufficiently fine tilth has been attained. The sowing season extends from the 1st of October to the end of November. In low lands, the sowings must be completed by the third week of October, but in the *chaparis,* where the land has to be ploughed, sowings may be continued to the end of November. About 12 to 18 seers of seed is required to sow an acre of land. When sown among paddy, the seeds are previously soaked in water for a night.

No after-treatment is required beyond fencing in and watching the crop in places where cattle-trespass is feared. A few showers of rain during the period of growth are beneficial to the crop, but rain at blossoming and harvesting time is injurious. The crop is harvested in March and April, *i.e.*, 6 to 7 months after the date of sowing. The harvesting and threshing are done in the same way as with *máti-máh* but the threshing is easier.

The *kalá* crop is very little subject to insect pests, but suffers from *khár-uthá* like *mát* and *magu-máh.*

Yield.

A yield of 12 maunds per acre would be considered a good ordinary outturn. The maximum yield may reach up to twice this amount. *Kalá* is the cheapest pulse grown in Assam, the price obtained by the cultivators in Lower Assam ranging usually from 12 annas to

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LENS ESCULENTA.

R1-8 per maund. In Upper Assam the market price would be about R2 per maund.

MASUR-MÁH.

Lens esculenta, *Moench.*

English—Lentil.

Bengali and Hindi—*Masur.*

Variety.—Only one variety of this pulse is known in cultivation. The kind grown in Assam has smaller seeds than the imported kind coming from Upper India.

Distribution. Soil.

Distribution and Soil.—Lentil is grown in the same kind of land as *áhu* and mustard. Usually it follows a broadcasted *áhu* crop and is sown in mixture with mustard. Its cultivation is chiefly confined to the *chaparis* of Kamrup, Nowgong, and Mangaldai. In Upper Assam it is cultivated to a small extent in the Majuli. The crop prefers a light loamy soil and an open situation.

Cultivation.

Cultivation.—The land is prepared for the crop in the same way as for *magu-máh* and *kálá.* It is sown in the first fortnight of November, and sowing must be completed by the middle of that month. As previously said, lentil is generally sown in mixture with mustard, but it is not uncommon to see it grown as an independent crop. About 6 seers of seeds are required for sowing an acre, when sown with mustard; sown singly about 50 per cent. more seed is required. No after-treatment is necessary.

Injuries.

Injuries.—The crop is singularly free from insect pests, but is subject to *khár-uthá,* to which most kinds of pulse are subject.

Harvesting.

Harvesting.—Lentil is harvested in March and April. It is threshed in the ordinary way, but although the pods are easily separated from the straw, they do not readily yield the seeds and require to be crushed in a mortar and pestle to secure this end.

Outturn.

Yield.—The usual yield of lentil is about 2 to 4 maunds to the acre. The price obtained by the cultivators ranges from R2-8 to R4 per maund.

Uses.

Use.—It is one of the pulses which is forbidden to Hindu widows, but in Assam the prohibition is confined to Brahman widows alone.

MATAR-MÁH.

PISUM ARVENSE.

Pisum arvense, *Linn.*

English name—Field pea.

Local name in Mangaldai—*Bataliá máh.*

Bengali—*Matar.*

Hindi—*Kerão.*

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Peas are seldom raised as an independent crop by Assamese cultivators. The little that they grow occurs in mixture with *kalá* (**Lathyrus sativus**) as stated in describing the cultivation of the latter. A separate description of its cultivation will, therefore, be superfluous. Peas are also sown mixed with mustard and *máti-máh* pulse. Time-expired coolies who have settled in Assam occasionally grow peas as a single crop, but the extent of such cultivation is very limited. The Assamese variety is of a very inferior description and is no doubt the result of degeneration. The writer has seen excellent samples of peas grown by up-country-men settled at Gauhati and Kamrup on the Assam-Bengal Railway.

KULTAHI-MAH.

Dolichos biflorus, *Linn.*

DOLICHOS BIFLORUS.

English name—Horse gram.

Assamese synonyms—*Kulthi-máh, kulat-máh, sulti-máh, chepti-máh.*

Bengali and Hindi—*Kurthi.*

Distribution.

Distribution.*—Kulthi-máh* is grown to a small extent in Kamrup and Darrang. In the Tezpur sub-division it is cultivated by Nepalese and coolie settlers. In Upper Assam and Nowgong, this pulse seems to be quite unknown.

Cultivation.

Cultivation.—Only one variety is known in Assam. The crop is grown in the same class of village lands as *máti-máh.* The method of cultivation and time of sowing and reaping are very much the same for both. About 5 seers of seed are sown per acre; thin seeding is desirable, the object being to allow the plants to creep and spread over ground. A good crop may yield up to 6 maunds of pulse per acre, but I believe the yield is usually very inferior.

Preservation.

Kulthi-mah—is also a cheap pulse, though it is seldom procurable in the market.

For preserving the seed, the grain is soaked in urine and then dried up with sand and by exposure to the sun. The seed is then stored either in earthen pots with a layer of sand on the top, or in *tomes* as is done with *máti-máh* seed.

Uses.

The main use of *kulthi* is either as *dál*, that is, split pulse, or in the form of meal. The grain has a nauseating fishy smell about it, and in either mode of using it, it should be fried before being split or ground into meal. *Khár* or Assamese alkali is added in cooking to soften the pulse.

Kulthi flour is also used in preparing a kind of native sweetmeat, esteemed as diet for women after confinement. It is considered wholesome and light of digestion.

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The Cultivation of Pulse Crops

CAJANUS INDICUS.

RAHAR-MÁH.

Cajanus indicus, *Spreng.*

Assamese synonyms—*Arhar, rahar dál, miri-máh, gáro-máh and gelá-máh.*
Bengali—*Arahar.*
Hindi—*Rahar.*

Distribution.

Distribution.—*Rahar* is grown in small quantities all over the valley. The usual practice is to grow it as a border crop round the sugar-cane fields, more for the protection of the cane crop than for the sake of its seeds. The stems are also utilized as fuel for boiling the cane juice. The plants are left to themselves and allowed to remain as long as they live. The Assamese think so little of the crop that they seldom take the trouble to gather the pods. As a field crop, *rahar* is seldom found in Assam except in small patches raised by coolie settlers. It is then treated as an annual crop. The variety so grown is probably distinct from the native variety grown by Assamese as a hedge crop.

Lac insect reared on the plant.

Synonyms.—*Rahar* is known by various names in the province. It is often spoken as *miri-máh* in Upper Assam and *gáro-máh* in the Lower districts, from the fact that it is one of the trees on which the Garos and the Miris rear the lac insect. Its name *gelá-máh* is derived from the fact that the pulse acquires a very soft consistency when boiled as *dál.*

Cultivation.

Cultivation.—The usual time for sowing is April and May. When grown around sugar-cane, the seeds are dibbled into the soil on the ridges enclosing the field. In field cultivation, the crop is sown in mixture with *áhu* rice or millets. The crop receives no further treatment. The pods ripen in March and April.

Grown around sugar-cane.

Variety.—The Assamese *rahar* is considered as inferior in flavour and taste to the imported kind, and does not cook so soft as the latter. It is believed that Assam-grown *rahar* is apt to cause giddiness, if eaten too often.

BEJIÁ-MÁH.

PUERARIA PHASEOLOIDES.

Pueraria phaseoloides, *Benth.*

This is a peculiar variety of pulse, which is perhaps not cultivated out of the Assam Valley, and even here it is far from being generally known. It is found in certain parts of North Kamrup and the Darrang district. The plant greatly resembles the *mung* pulse in its leaves and pods, but unlike the latter, it is a creeper and the pods

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are thin and long resembling needles more or less, from which fact the plant derives its distinctive name of *bejia* or needle pulse.

The seeds are also elongated and of a pale yellow colour not unlike that of the Bengal *sona-mug*. A black-seeded variety is also said to be known, but it must be comparatively rare.

The plant is an extensive creeper. The usual mode of growing it is to dibble in the seeds at short intervals along the fences put up around sugar-cane fields and allow the plants to creep over them. The crop is also grown in mixture with *áhu* rice in the same way as the *soy-bean*. May and June are the proper months for putting down the seeds, and the plants begin to bear about six months later. They continue to flower and fruit all through the cold weather, the pods being plucked from time to time as they become ripe. Delay in plucking may cause the pods to burst and shed their seeds. A large creeper may extend along the fence for many yards on either side, and it is said a single plant may yield up to 5 seers of pulse.

The green seeds may be eaten raw or used in vegetable curries. Ripe seeds are also used as *dál*. The pulse has an unpleasant fishy smell about it and is not much liked.

PÁTÁNI JOKRÁ.

Glycine hispida, *Maxim.*

GLYCINE HISPIDA.

English name—Soy-bean.
Bengali name—*Chhai.*

The Soy-bean.

Soy-bean is little known in the Assam Valley. The Barpeta subdivision is the only part of the valley, from which its cultivation has been reported. The pulse is, however, extensively grown in the Khasi Hills. In Barpeta the crop is sown mixed with *áhu* in April and May. About 5 seers of seed are sown per acre. The *áhu* crop is removed in July and August, but the bean crop remains on the ground till December or January. The *áhu* stubble acts as support to the bean plants. About November it puts forth its blossom. The crop becomes ready for the harvest in December and January. The mode of harvesting it and its subsequent treatment and use are precisely the same as for *kulthi-máh*. The crop is grown entirely for home consumption.

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FOOD GRAINS AND FODDERS.

(INDIA.)

(*Dictionary of Economic Products, Vol. III.*, F. 669-74.)

Consult Agricultural Ledger No. 10 of 1901.

INDIAN FOOD GRAINS AND FODDERS: THEIR CHEMICAL COMPOSITION, II.

By DR. J. WALTER LEATHER, F.I.C., F.C.S., *Agricultural Chemist to the Government of India.*

INTRODUCTORY.

The chemical composition of a number of Indian food grains and fodders was detailed in *Agricultural Ledger* No. 10 of 1901. As indicated in the opening paragraph it was anticipated that these might be amplified at an early date and the anticipation is fulfilled in the following pages.

Arrangement of subject matter.

2. The subject matter of this Ledger is supplied in two forms. In Part II. will be found the analyses of the individual samples, from a study of which the reader can tell to what extent variations occur. They are arranged alphabetically under the botanical names. In Part I. the numerical averages of these analyses are brought together in six statements, including cereals, pulses, oilseeds and dry and green fodders. In addition to the botanical names, the synonyms, and the English and more common vernacular names are inserted. To have given the whole of the latter would not have tended to simplify the procedure when searching for any particular subject. A complete index is also added.

Andropogon Sorghum.

3. Reference must be made to two plants. **Sorghum vulgare** is now more usually called **Andropogon Sorghum** and falls, therefore, under A. Also the botanical names of Mung and Urd have been recently reversed by Dr. Prain, who has shown that Urd is the plant which Linnæus named **Phaseolus Mungo** and Mung

Phaseolus Mungo.

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the one to which he gave the name **P. radiatus**. This correction has been recognised by botanists and is therefore adopted.

Seeds not decorticated.

4. The seeds are all, unless otherwise specially indicated as in the case of rice, analysed entire. In some cases, however, a knowledge of the composition of the decorticated grain is desirable. So, likewise, is that of the ash. This information will be supplied later.

5. The source, from which the samples have been obtained, is stated. Some few of the analyses were made during the time Mr. S. H. Collins held charge of the Laboratory, and their authorship is hereby acknowledged. These analyses are marked with a †.

Analyses of some of the principal Madras fodders were made by Colonel J. L. Van Geyzel in 1890 and published in Bulletin No. 6 of the Madras Agricultural Department. The average of these have been inserted in Part I.

Methods of Analysis.

6. A word of explanation may be given regarding the methods of analysis employed. These are not quite uniformly the same in all countries, and consequently the published analyses of food-stuffs are not always comparable in details. The following notes are therefore made.

7. The ***Moisture*** has been determined in air-dry materials by drying in an air-oven at about 100°C. Green-fodders had to be dealt with specially. About 100lbs. of the freshly cut plant was weighed and spread out on a " durry " in the sun. The weight of fodder was taken each evening until it ceased to lose weight; after recording the last weight, it was chaffed and either the whole or a definite portion was sent for analysis. The percentage of water given in Part II. for these materials shows, therefore, the amount as really in the green plant at the time of cutting.

8. The ***Oil*** has been extracted from the *air-dry* sample with rectified, and partially desiccated, ether. This ether extract consists of true oil in the case of seeds generally. But in green fodders, straw and " bhusa " it includes wax, chlorophyl, alkaloids, etc., besides oil.

9. The ***Albuminoids.***—In some of the older samples the proportion of albuminoid nitrogen (from which the amount of albuminoids is calculated) was not separately determined; for these the amount of *total* Nitrogen has been multiplied by the usual factor 6·25, and the product entered as albuminoids. All such have been marked with an * . In calculating the averages for Part I., such analyses have usually been excluded as they are obviously too high. With few exceptions, however, the albuminoids were precipitated by cupric hydrate (Ritthansen's and Stutzer's method) and their Nitrogen determined by Kjeldahl's method.

10. ***Soluble Carbohydrates.***—This term is applied to that

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part of the grain or fodder which is not determined chemically. It is obtained by deducting the sum of the other constituents from 100. In German and American literature it is called "Nitrogen free extract."

In seeds, the English term is approximately correct and it is then principally starch or mucilage with some sugar. But in fodders the term is misleading. More detailed information is much to be desired, but unfortunately the separate determination of the materials which fall under this head is tedious for some, and impossible for others.

11. The ***Woody fibre*** has been determined in all cases by the almost universal method of separating the proteids and soluble carbohydrates with acid and alkali, and determining the fibre which remains undissolved. This fibre includes principally cellulose and lignin.

12. ***Mineral matter.***—This includes principally phosphates of potash, lime and magnesia, a little sulphate and sand and silica. Any earth adhering to the sample would be included. In order to show the relative composition of this mineral matter more clearly, the silica belonging to the seed, together with the sand of any earthy matter adhering to the sample, has been shown separately from the other (the soluble) mineral matter. The soluble mineral matter is hardly affected by adhering dirt and any variations which occur in its proportion depend on the nature of the seed. On the other hand a dirty sample would be indicated by an abnormal amount of "Sand and Silica." If, among a series of samples of grain, this figure is uniform, it may be assumed that it is silica properly belonging to the seed; whilst if one or more of the samples of a series contain much more Sand and Silica than the others, this excess is caused by adhering dirt. Most of the samples of grain were very clean.

FOOD GRAINS, etc.

Indian Food Grains and Fodders:

PART I.

I.—Average composition of Cereal Grain.

No. of analyses		Moisture.	Oil.	Albuminoids.	Soluble carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	Andropogon Sorghum.									
11	(*Juar, Cholum*)	10·71	3·69	9·71	72·38	1·54	1·81	·24	1·64	1·55
	Avena sativa.									
3	(Oats)	10·47	5·69	7·68	59·38	12·33	1·53	2·93	1·32	1·14
	Coix Lachryma-Jobi.									
1	(Job's tears)	11·29	4·93	9·44	60·13	6·56	1·85	5·80	1·58	1·51
	Eleusine Coracana.									
6	(*Ragi. Murua*)	12·70	1·22	6·40	71·08	2·92	2·83	2·85	1·13	1·03
	Hordeum vulgare.									
4	(Barley) (common) . . .	12·39	1·85	6·62	71·55	4·16	1·58	·80	1·26	1·06
3	Ditto (huskless) . . .	12·14	1·81	9·55	72·60	1·90	1·61	·39	1·57	1·53
	Oryza sativa.									
4	Undecorticated Paddy, fine . .	12·55	2·14	6·35	65·29	7·84	1·39	4·44	1·09	1·01
4	Ditto coarse .	12·81	2·04	5·91	64·27	8·75	1·41	4·81	1·06	·94
4	Clean Rice, fine	12·25	·92	6·45	78·83	·21	·82	·51	1·19	1·03
4	Ditto, coarse	12·10	1·03	6·91	77·99	·45	1·03	·54	1·15	1·10
	Panicum frumentaceum.									
1	(*Sawan. Besuiti*)	7·72	4·39	7·06	67·56	7·44	1·70	4·13	1·18	1·13
	Panicum miliaceum.									
3	(*Varagu*)	8·84	4·57	8·04	65·20	7·39	2·16	3·79	1·36	1·29

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	Paspalum sanguinale.									
1	......	12·28	3·06	10·63	60·03	6·96	2·44	3·60	1·79	1·70
	Paspalum scrobiculatum.									
1	(*Kodra*)	8·01	3·36	5·81	70·06	8·47	1·34	2·95	1·00	·93
	Pennisetum typhoideum.									
6	(Spiked Millet)	8·77	5·33	9·52	73·52	·78	1·73	·35	1·61	1·51
	Setaria italica.									
4	(Italian Millet)	10·02	4·32	10·44	65·29	5·98	2·10	1·85	1·80	1·67
	Triticum sativum.									
7	(Wheat) *White, soft*	13·33	1·76	9·74	70·18	2·10	2·34	·64	1·68	1·65
1	*White, hard*	9·94	1·50	9·25	75·96	1·50	1·80	·05	1·57	1·48
	Red, soft	13·44	1·84	10·71	69·33	2·36	2·05	·33	1·84	1·71
6	*Red, hard*	13·27	1·60	10·90	68·93	2·61	2·20	·28	1·88	1·74
	Zea Mays.									
8	(Maize)	10·58	4·81	9·66	71·59	1·43	1·76	·16	1·62	1·55
	Bye-Products.									
	Oryza sativa.									
8	Paddy husks	8·58	2·54	3·85	34·75	29·24	2·41	18·62	·71	·61
2	Rice bran	8·21	8·31	5·72	34·25	25·18	3·55	14·79	1·03	·91
	Triticum sativum.									
4	Wheat bran	11·84	3·50	13·20	58·42	8·42	4·59	·38	2·30	2·1

II.—Average composition of Pulse Grain.

	Cajanus indicus.									
6	(*Arhar.* Tor)	10·13	1·34	17·56	61·36	5·78	3·63	·15	3·18	2·81
	Cicer aretinum.									
7	(Gram, *chana*)	9·98	4·39	18·14	57·94	6·40	2·95	·20	3·20	2·93

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FOOD GRAINS, etc.

Indian Food Grains and Fodders:

II.—Average composition of Pulse Grain—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
2	**Cyamopsis psoralioides.** (*Guar, kurti*) . . .	9·83	2·81	27·29	48·18	8·08	3·57	·28	4·71	4·36
2	**Dolichos uniflorus.** (Horse gram) . .	8·82	·80	18·18	62·29	4·13	3·92	1·84	3·57	2·91
6	**Dolichos Lablab.** (*Wal*)	9·59	1·25	21·35	57·23	6·57	3·65	·36	3·69	3·42
1	**Lathyrus sativus.** (*Khesari*)	7·89	·79	24·69	57·98	4·28	3·18	1·19	4·21	3·95
1	**Lens esculenta.** (Lentil)	8·03	1·06	23·00	61·14	2·42	3·54	·81	3·94	3·68
3	**Phaseolus aconitifolius.** (*Moth*)	9·94	·86	20·00	60·58	4·60	3·67	·35	3·58	3·20
6	**Phaseolus Mungo.** (*Urd*)	9·97	·93	20·73	59·99	3·81	3·53	1·02	3·59	3·30
5	**Phaseolus radiatus.** (*Mung*)	10·38	1·07	21·22	59·58	3·80	3·70	·42	3·82	3·40
1	**Pisum arvense.** (Field pea)	10·56	·93	20·12	61·34	4·46	2·54	·05	3·45	3·22
3	**Pisum sativum.** (Garden pea)	10·12	1·21	20·02	60·61	4·79	2·94	·31	3·52	3·20

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	Vigna Catjang.									
2	(*Chaoli*)	8·85	1·38	18·47	64·30	3·20	3·50	·29	3·20	2·95
	III.—Average composition of Oil-seeds.									
	Brassica Napus.									
3	(Indian rape)	6·69	39·46	18·29	23·18	5·24	4·29	2·84	3·17	2·93
	Brassica juncea.									
4	(Indian mustard)	7·68	38·26	19·14	24·10	5·48	4·28	1·06	3·31	3·06
	Brassica campestris.									
5	(Indian colza, Sarson) . . .	7·21	41·82	20·09	22·04	4·47	3·96	·39	3·47	3·21
	Carthamus tinctorius.									
4	(Safflower)	6·22	26·88	13·38	22·93	27·67	2·10	·66	2·48	2·14
	Eruca sativa.									
1	(*Sihuan*)	6·50	33·45	24·88	24·21	4·29	4·02	2·65	4·23	3·98
	Gossypium herbaceum.									
3	(Cotton seed)	9·82	18·65	17·31	31·15	19·01	3·63	·43	3·00	2·77
	Guizotia abyssynica.									
3	(Niger seed)	6·48	39·12	19·31	14·68	12·16	5·14	2·86	3·17	3·09
	Linum usitatissimum.									
2	(Linseed)	5·80	40·31	17·91	26·12	5·27	3·81	·72	3·19	2·87
	Papaver somniferum.									
1	(Poppy)	4·07	48·95	17·75	16·99	5·09	6·85	·30	2·97	2·84
	Ricinus communis.									
1	(Castor oil seed)	6·43	45·28	14·00	10·59	19·58	2·94	·18	2·36	2·24
	Sesamum indicum.									
8	(Ginjelly)	4·73	49·13	19·32	15·28	4·21	6·52	·80	3·27	3·08

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FOOD GRAINS, etc.

Indian Food Grains and Fodders :

IV.—Average composition of Cereal Straw.

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
4	**Andropogon Sorghum.** (Great Millet)	8·91	2·46	3·21	46·22	26·58	3·25	9·98	·58	·51
1	**Avena sativa.** (Oat straw)	9·88	1·97	3·00	41·31	30·13	6·45	7·26	·53	·48
7	**Oryza sativa.** (Rice straw)	10·22	1·23	2·56	40·46	29·49	3·71	12·28	·47	·41
6	**Triticum sativum.** (Wheat straw)	8·71	·98	3·01	37·93	35·69	4·14	9·79	·58	·48
	(Average analysis by Van Guyzel, Madras Bulletin No. 6.)									
14	**Eleusine Coracana.** (*Ragi*)	9·88	2·37	2·19	45·24	28·22	12·10		...	...
8	**Oryza sativa.** (Rice straw)	8·12	2·19	1·78	41·02	30·02	16·87		...	...
5	**Paspalum scrobiculatum.** (*Varagu* straw)	8·71	2·51	1·97	47·92	28·84	10·05		...	...
14	**Peninsetum typhoideum.** (*Cumbu* straw)	7·07	1·33	1·94	43·99	37·63	8·04		...	...
4	**Andropogon Sorghum.** (*Cholum* straw)	8·06	3·14	1·61	49·18	30·93	7·08		...	...

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V.—Average composition of Pulse "bhusa."

5	**Cajanus indicus.** (Pigeon pea) *Bhusa*	8·81	4·40	11·01	44·67	19·23	6·11	5·76	1·99	1·76
3	**Cicer arietinum.** (Bengal gram) *Bhusa*	8·41	2·27	3·65	45·86	26·71	9·91	3·20	·75	·58
1	**Dolichos uniflorus.** (Horse gram) *Bhusa*	5·60	2·63	5·25	49·66	28·01	6·54	2·31	1·09	·84
1	**Dolichos Lablab.** (*Wal*) *Bhusa*	9·92	3·72	13·37	43·04	16·17	11·27	2·51	2·56	2·14
2	**Lathyrus sativus.** (*Khesari*) *Bhusa*	8·59	3·96	9·50	44·21	19·97	9·98	3·79	1·81	1·44
1	**Phaseolus Mungo.** (*Urd*) *Bhusa*	15·96	1·70	11·19	39·14	17·08	9·97	4·96	2·03	1·79
1	**Phaseolus radiatus.** (*Mung*) *Bhusa*	13·30	2·52	10·88	40·35	18·66	10·38	3·91	1·85	1·74
2	**Pisum sativum.** (Pea) *Bhusa*	8·57	3·02	10·84	42·63	20·81	9·50	6·12	2·49	1·73

(Calculated for 10 per cent. moisture)

VI.—Average composition of Green Fodders.

6	**Andropogon Sorghum.** (Green *juar*)	10·00	1·41	4·01	43·69	30·83	4·60	6·22	·86	·65
1	**Avena sativa.** (Green oats)	10·00	2·02	5·13	49·14	21·78	8·03	3·93	1·04	·82
1	**Brassica campestris.** (Green sarson)	10·00	3·05	13·00	30·16	20·41	16·31	7·21	2·66	2·08
1	**Eleusine Coracana.** (Green madal)	10·00	2·25	9·11	36·86	25·26	10·70	5·82	2·25	1·46

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FOOD GRAINS, etc.

Indian Food Grains and Fodders :

VI.—Average composition of Green Fodders—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	Hordeum vulgare.									
1	(Green barley)	10·00	1·98	10·85	36·16	28·84	9·44	2·42	2·03	1·76
	Medicago sativa.									
2	(Green lucerne)	10·00	3·11	13·94	47·35	14·55	10·66	·45	3·11	2·21
	Melilotus parviflora.									
1	(Green *singi*)	10·00	2·08	15·52	35·54	23·83	10·79	2·25	2·97	2·47
	Panicum jumentorum.									
2	(Guinea grass)	10·00	2·63	6·23	45·79	20·09	6·20	9·17	1·30	1·00
	Phaseolus aconitifolius.									
1	(*Moth*)	10·00	3·16	11·36	42·60	17·71	10·47	4·50	2·43	1·82
	Setaria italica.									
1	(Green *kangni*)	10·00	2·09	8·07	39·11	24·71	7·06	9·00	1·86	1·28
	Sorghum saccharatum.									
2	(Sugar sorghum)	10·00	...	2·53	38·94	38·52	3·26	6·74	·56	·40
	Triticum sativum.									
1	(Green wheat)	10·00	2·07	9·70	39·24	26·31	7·89	4·83	1·66	1·56
	Zea Mays.									
1	(Green maize)	10·00	2·52	9·17	37·76	25·25	8·44	6·82	1·95	1·51
2	Silage	8·48	1·31	3·66	46·55	29·63	3·66	7·14	·72	·59
5	Grass (good) . . .	9·77	...	4·54	46·47	30·58	3·36	5·44	·88	·69
11	" (poor) . . .	11·04	...	1·77	45·21	32·38	2·25	7·51	·31	·28

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PART II.

Andropogon Sorghum, *Brot. Roxb.*

Syn. : Sorghum vulgare, *Pers.*

English : The Indian or Great Millet, Guinea Corn.

Vern. : *Juar, cholum.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN.									
273/99	"Khend," Poona . . .	9·98	3·61	11·87	71·54	1·12	1·83	·05	1·96	1·81
278/99	"Nilwa," Poona	10·43	4·45	11·19	70·99	1·18	1·73	·05	1·91	1·79
279/99	"Dudh mogra," Poona . .	10·21	4·13	10·19	71·90	1·22	2·11	·24	1·74	1·63
280/99	"Mal dandi," Poona . . .	8·76	3·47	9·57	74·20	1·75	1·92	·33	1·65	1·53
281/99	"Sundia," Poona . . .	9·90	4·59	12·44	70·05	·79	1·83	·40	2·11	1·99
42/00	Brown, Panjáb	11·33	3·16	8·94	71·88	2·09	1·90	·70	1·49	1·43
56/00	White, Panjáb	12·04	3·13	8·19	73·44	1·37	1·64	·19	1·34	1·31
404/00	Red, Ghazipur	11·25	3·29	9·44	72·37	1·56	1·81	·28	1·62	1·51
405/00	White, Agra	11·71	3·84	7·99	72·99	1·36	1·82	·29	1·34	1·27
406/00	White, Cawnpur	11·37	3·58	8·19	73·46	1·66	1·64	·10	1·39	1·31

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Andropogon Sorghum, *Brot. Roxb.*—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN—*contd.*									
407/00	Dwarf brown, Cawnpur	10·86	3·39	8·81	73·40	1·81	1·68	·05	1·48	1·41
	11 Samples, average	10·71	3·69	9·71	72·38	1·54	1·81	·24	1·64	1·55
	"BHUSA."									
9/98	Nagpur	12·61	...	2·24	45·95	25·42	3·22	10·56	·48	·36
†174/98	"Sundia," not quite ripe, Poona	8·04	2·19	3·83	47·98	27·90	2·91	7·15	·64	·61
†175/98	"Kawbi," not quite ripe, Poona	7·35	2·11	2·29	46·27	31·38	3·45	7·15	·41	·37
148/00	Samalkota, Madras	7·63	3·09	4·50	44·67	21·64	3·42	15·05	·81	·72
	4 Samples, average	8·91	2·46	3·21	46·22	26·58	3·25	9·98	·58	·51
	GREEN FODDER.									
19/96	Reaped green, Nagpur	69·76	...	·55	14·74	11·90	1·17	1·88	·113	·088
21/96	Reaped ripe, Nagpur	67·02	...	·64	16·42	12·78	1·52	1·62	·173	·103
317/96	Cut in October, Cawnpur	56·10	...	3·10	20·65	15·32	2·29	2·54	·560	·500
318/96	Cut in March, Cawnpur	63·77	...	1·54	18·50	10·35	1·77	4·07	·420	·250
†27/98	" Madras	80·24	·46	1·21	9·71	6·15	1·09	1·14	·227	·193

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583/00	„ Panjáb . . .	80·27	·51	1·24	8·87	6·18	1·51	1·42	·235	·198
	6 Samples, average (fresh) . .	69·52	·48	1·36	14·81	10·45	1·56	2·11	·291	·222
	Ditto, ditto (dry) : .	10·00	1·41	4·01	43·60	30·83	4·60	6·22	·86	·65

Avena sativa, *Linn.*

English : Oats.

Vern. : *Jai.*

GRAIN.

6/98	Dehra Dun	10·17	5·27	6·39	61·57	11·29	1·89	3·42	1·18	1·02
173/93	Cape Oats, Cawnpur, United Provinces	10·80	5·93	8·77*	57·95	12·50	1·25	2·80	1·40	...
427/00	Cape Oats, Cawnpur, United Provinces	10·43	5·86	7·87	58·62	13·20	1·44	2·58	1·37	1·26
	3 Samples, average . . .	10·47	5·69	7·68	59·38	12·33	1·53	2·93	1·32	1·14

GREEN FODDER.

230/00	Green Oats, Panjáb . . .	83·51	·37	·94	9·00	3·99	1·47	·72	·19	·15
	„ Dry state	10·00	2·02	5·13	49·14	21·78	8·03	3·93	1·04	·82

STRAW.

447/00	Cape Oat-straw, Cawnpur, United Provinces	9·88	1·97	3·00	41·31	30·13	6·45	7·26	·53	·48

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FOOD GRAINS, etc. Indian Food Grains and Fodders :

Brassica juncea, *H. f. & T.*

Syn.: SINAPIS JUNCEA, *Linn.* SINAPIS RAMOSA, *Roxb.*
English: Indian Mustard.
Vern.: *Asl-rai.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	24-PARGANAS.									
380/00	"Kajli sarsa," Bengal	7·61	40·22	18·44	22·79	5·50	4·01	1·43	3·11	2·95
385/00	Lalki tori, Dumraon, Bengal	8·48	39·46	18·19	24·07	5·75	3·87	·18	3·18	2·91
518/00	Rai, Nadia, Bengal	7·68	32·51	21·94	26·07	5·56	4·89	1·35	3·84	3·51
520/00	Rai, Arraria, Bengal	6·95	40·84	18·00	23·47	5·12	4·34	1·28	3·10	2·88
	4 Samples, average	7·68	38·26	19·14	24·10	5·48	4·29	1·06	3·31	3·06

Brassica Napus, *Linn.; var.* Dichotoma.

English: Indian Rape.
Vern.: *Tori, Lutni, Maghi.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
388/00	Latni, Hazaribagh, Bengal	7·38	38·21	19·06	23·21	5·06	4·14	2·94	3·29	3·05
496/00	Lotni, Ranchi, Bengal	6·48	40·00	17·50	21·54	5·35	4·18	4·95	3·04	2·80
519/00	Jehanabad, Bengal	6·21	40·18	18·32	24·80	5·30	4·56	·63	3·18	2·93
	3 Samples, average	6·69	39·46	18·29	23·18	5·24	4·49	2·84	3·17	2·93

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Brassica campestris, *Linn.*; *var* Sarson, *Prain.*

English: Indian Colza.

Vern.: *Sarson, Sweti.*

383/00	Piarka tori, Dumraon, Bengal .	7·18	41·51	22·25	20·30	4·44	3·90	·42	3·87	3·56
384/00	Lalka tora, Dumraon, Bengal .	7·10	39·73	19·94	20·91	8·16	4·07	·09	3·36	3·19
386/00	Piarki tori, Dumraon, Bengal .	7·95	41·42	20·88	22·31	3·32	3·67	·45	3·50	3·34
389/00	Seta Sarisa, Rungpore, Bengal .	7·14	42·62	18·63	23·52	3·43	4·02	·64	3·26	2·97
521/00	Arrah, Bengal	6·71	43·92	18·75	23·17	2·99	4·12	·34	3·34	3·00
	5 Samples, average . . .	7·21	41·82	20·09	22·04	4·47	3·96	·39	3·47	3·21
	GREEN FODDER.									
232/00	Green Sarson, Panjáb . . .	86·13	·47	2·00	4·64	3·14	2·51	1·11	·41	·32
	" Dry state . .	10·00	3·05	13·00	30·16	20·41	16·31	7·21	2·66	2·08

Cajanus indicus, *Spreng.*

Syn.: CYTISUS CAJAN, *Linn.*

English: PIGEON Pea, Congo Pea.

Vern.: *Arhar, Tor, Tur.*

	GRAIN.									
79/99	Red, Poona	8·08	1·32	19·38	61·39	5·94	3·80	·09	3·35	3·10
90/99	White, Poona	7·92	1·23	18·69	62·64	5·99	3·44	·09	3·44	2·99

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FOOD GRAINS, etc. **Indian Food Grains and Fodders:**

Cajanus indicus, *Spreng.—contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN—*contd.*									
271/99	White, Poona	8·64	1·91	19·19	60·58	5·24	3·86	·58	3·41	3·07
203/00	"Dark-red Kandulo," Ganjam, Madras	14·33	1·31	17·25	56·95	6·55	3·56	·05	3·25	2·76
418/00	White, Cawnpur	10·87	1·46	14·25	63·68	6·22	3·45	·05	2·74	2·28
419/00	Red, Cawnpur	10·94	1·03	16·62	62·92	4·76	3·68	·05	2·88	2·66
	6 Samples, average	10·13	1·34	17·56	61·36	5·18	3·63	·15	3·18	2·81
	"BHUSA" (pods and leaves from the threshing floor).									
54/99	"White," Poona	6·77	6·93	13·25	45·38	18·10	6·44	3·13	2·45	2·12
5/99	"Red," Poona	6·22	7·94	14·94	46·51	14·35	6·12	3·92	2·60	2·39
266/99	Poona	8·89	2·97	7·38	49·94	21·74	6·46	2·62	1·42	1·18
204/00	Rajamundry, Madras	11·97	1·39	9·19	40·43	20·89	4·59	11·54	1·61	1·47
446/00	Cawnpur District	10·23	2·78	10·31	41·08	21·08	6·92	7·60	1·85	1·65
	5 Samples, average	8·81	4·40	11·01	44·67	19·23	6·11	5·76	1·99	1·76

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Carthamus tinctorius, *Linn*,

English.: Safflower; American Saffron.

Vern.: *Kusum.*

GRAIN.

95/95	Poona	7·49	31·84	13·31*	18·66	26·31	2·39		2·13	...
15/98	Poona †	5·11	27·08	8·41	22·58	32·69	1·83	·30	2·17	1·34
92/99	Poona	6·04	18·28	20·44	27·51	23·60	3·78	·35	3·77	3·27
437/00	Cawnpur District, United Provinces	6·23	29·33	11·37	22·97	28·08	·68	1·34	1·87	1·82
	4 Samples, average . . .	6·22	26·88	13·38	22·93	27·67	2·10	·66	2·48	2·14

Cicer arietinum, *Linn.*

English: Common Gram, Bengal Gram, Chick Pea.

Vern.: *Chana, Chhola, But.*

GRAIN.

24/98	Red *var.*, Dehra Dun . . .	9·88	3·95	17·05	60·03	6·51	2·40	·18	...	2·98
82/99	Red *var.*, Poona	7·99	3·89	21·37	54·97	8·32	3·16	·30	3·73	3·42
272/99	Red *var.*, Poona	8·60	5·31	15·50	60·13	7·21	3·06	·19	2·71	2·40
425/00	Red *var.*, Cawnpur . . .	11·18	3·13	21·00	53·55	8·14	2·91	·09	3·69	3·36

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Cicer arietinum, *Linn.*—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN—*contd.*									
426/00	White *var.*, Large Kabali, Cawnpur .	10·36	4·22	22·81	57·48	1·93	3·15	·05	4·05	3·65
635/00	White *var.*, Small, Jabalpur . .	10·80	5·01	15·19	60·93	4·41	3·12	·54	2·63	2·43
636/00	Red *var.*, Jabalpur . . .	11·04	5·25	14·06	58·47	8·30	2·84	·04	2·42	2·25
	7 Samples, average . . .	9·98	4·39	18·14	57·94	6·40	2·95	·20	3·20	2·93
	BHUSA (pods and leaves from the threshing floor).									
57/99	Poona	6·56	2·69	3·06	44·55	28·93	9·29	4·92	·68	·49
264/99	Poona	8·21	2·64	2·94	49·70	21·87	11·81	2·83	·67	·47
445/00	Cawnpur	10·46	1·48	4·94	43·33	29·33	8·62	1·84	·90	·79
	3 Samples, average . . .	8·41	2·27	3·65	45·86	26·71	9·91	3·20	·75	·58

Cocos nucifera, *Linn.*

English: Cocoanut.

Vern: *Náriyal, Narikel.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	CAKE.									
23/†98	Poona	7·72	16·53	13·62	44·57	12·45	4·65	·46	3·31	2·17

Coix Lachryma-Jobi, *Linn.*

Syn.: C. ARUNDINACEA, *Lamk.*

English: Job's tears.

Vern.: *Kasai Bij, Ran Jandhla, Ran Makai.*

GRAIN.

478/00	U. Soh view, Hill Districts, Assam	11·29	4·93	9·44	60·13	6·56	1·85	5·80	1·58	1·51

Crotalaria juncea, *Linn.*

Syn.: C. TENUIFOLIA, *Roxb.*

English: Sunn Hemp.

Vern.: *San, Sanai.*

FODDER.

184/00	Rajamundry, Madras . . .	14·39	1·12	11·31	35·85	27·39	6·43	3·51	2·29	1·99

Cyamopsis psoralioides, *DC.*

English: Chester Bean.

Vern.: *Guar, Khurti.*

GRAIN.

108/99	Poona	8·99	2·99	28·31	48·42	7·68	3·32	·29	4·93	4·53
442/00	Cawnpur	10·67	2·63	26·18	47·94	8·49	3·82	·27	4·49	4·19
	2 Samples, average . . .	9·83	2·81	27·29	48·18	8·08	3·07	·28	4·71	4·36

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Dolichos uniflorus, *Lamk.*

Syn. : D. BIFLORUS, GLYCINE UNIFLORUS, *Lam.*

English : Horse Gram.

Vern. : *Kûlthi.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN.									
101/99	Poona	7·45	·89	20·06	60·62	4·57	4·34	2·07	3·74	3·21
173/00	Berhampur, Madras Presidency .	10·20	·72	16·31	63·96	3·69	3·51	1·61	3·40	2·61
	2 Samples, average . . .	8·82	·80	18·18	62·29	4·13	3·92	1·84	3·57	2·91
	BHUSA (pods and leaves from the threshing floor).									
149/00	Berhampur, Madras Presidency .	5·60	2·63	5·25	49·66	28·01	6·54	2·31	1·09	·84

Dolichos Lablab, *Linn.*

Vern. : *Wal, lobia.*

	GRAIN.									
106/99	White *var.*, Poona . . .	7·11	·93	23·31	56·98	6·94	3·99	·74	4·06	3·73
267/99	White *var.*, Poona . . .	9·55	2·03	23·44	53·26	7·42	4·20	·10	4·07	3·75

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268/99	White *var.*, "Kadawa," Poona .	9·08	1·11	20·75	58·38	6·78	3·85	·05	3·46	3·32
269/99	Large white *var.*, "Damania," Poona	9·70	1·14	19·56	61·94	4·69	2·92	·05	3·24	3·13
270/99	"Watania," Poona . . .	9·19	1·17	23·31	55·35	6·12	3·69	1·17	3·98	3·73
189/00	Red *var.*, Rajamundry . . .	12·90	1·12	17·75	57·46	7·48	3·24	·05	3·31	2·84
	6 Samples, average . . .	9·59	1·25	21·35	57·23	6·57	3·65	·36	3·69	3·42

BHUSA (pods and leaves from the threshing floor).

263/99	Poona	9·92	3·72	13·37	43·03	16·17	11·27	2·51	2·56	2·14

Eleusine Coracana, *Gærtn.*

Syn. : CYNOSURUS CORACANUS, *Linn.*

Vern. : *Nagli, Ragi, Bavto, Murua, Kodon.*

GRAIN.

87/99	Poona	9·38	1·38	5·37	78·46	2·47	2·47	·47	·95	·86
47/00	Panjáb	12·33	1·09	6·12	73·11	3·45	3·46	·44	1·23	·98
195/00	"Bhuddai" or "Bhudo Mundya," Ganjam, Madras . . .	14·12	1·26	7·69	66·95	3·26	2·69	4·03	1·41	1·23
196/00	"Boda Mundya," Ganjam, Madras	13·06	1·39	6·31	66·91	2·35	2·82	7·16	1·09	1·01
197/00	"Rinjya or Rinja Mundya," Ganjam, Madras	13·27	1·15	6·94	66·72	3·67	3·28	4·97	1·12	1·11

Eleusine Coracana, *Gœri.—contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	Grain—*contd.*									
475/00	"U. Rai-truh," Hill Districts, Assam . . .	14·03	1·03	6·00	74·31	2·33	2·25	·05	1·01	·96
	6 Samples, average . . .	12·70	1·22	6·40	71·08	2·92	2·83	2·85	1·13	1·03
	Green Fodder.									
586/00	"Madal," Panjáb	80·83	·48	1·94	7·85	5·38	2·28	1·24	·478	·310
	,, (Dry state) . . .	10·00	2·25	9·11	36·86	25·26	10·70	5·82	2·25	1·46

Eruca sativa, *Linn.*

Syn.: Brassica eruca, *Linn.*, B. erucoides, *Roxb.*

Vern.: *Sihuan.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	Grain.									
435/00	Sihuan, Cawnpur . . .	6·50	33·45	24·88	24·21	4·29	4·02	2·65	4·23	3·98

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Gossypium herbaceum, *Linn.*

English: Cotton.

Vern. : *Sarki, Kapasia.*

SEED.

301/99	Egyptian seed	6·75	28·40	22·63	21·06	16·71	4·19	·26	3·78	3·63
439/00	"Hybrid," Cawnpur	9·93	17·78	15·06	31·05	22·30	3·37	·50	2·52	2·41
440/00	"Cook's long staple," Cawnpur	10·26	19·49	20·75	27·03	18·10	3·97	·40	3·57	3·32
441/00	"Cawnpur" *var.*, Cawnpur	9·26	18·68	16·13	35·38	16·62	3·55	·38	2·91	2·59
	3 Samples, average	9·82	18·65	17·31	31·15	19·01	3·63	·43	3·00	2·77

Grass.

Vern. : *Ghás, Gavat.*

17/95	Plumed grass, Juhi, Cawnpur	10·07	...	4·45	50·80	29·76	2·37	2·55	·86	·71
209/95	Cut dry, Nagpur	9·81	...	1·54	39·39	34·58	2·67	12·01	·26	·25
210/95	Cut green, Nagpur	9·23	...	2·46	44·16	31·75	1·74	10·66	·41	·39
295/95	Kaira District, Gujrat	8·72	...	2·45	45·87	34·48	1·10	7·38	·45	·39
122/97	Aligarh, United Provinces	6·87	...	5·60	48·99	30·08	3·15	5·31	1·05	·89
396/94	Aligarh, United Provinces	13·83	...	3·56	48·16	25·42	3·64	5·39	...	·57

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Grass—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
368/00	Navapur, Bombay . . .	12·33	...	2·12	51·21	27·16	2·83	4·28	·37	·34
369/00	Thana, Bombay	12·21	...	1·50	39·13	35·54	4·30	7·32	·25	·24
370/00	Saugor, Central Provinces . .	12·59	...	2·07	49·89	28·11	2·55	6·79	·35	·33
371/00	Jabalpur, Central Provinces . .	11·78	...	2·31	43·51	33·66	2·38	6·36	·37	·37
372/00	Budni, Central Provinces . .	11·36	...	1·31	44·42	35·24	1·99	5·68	·21	·21
373/00	Central Provinces	11·77	...	1·50	47·59	27·69	2·50	8·97	·31	·24
377/00	Bhopal	10·78	...	·94	43·92	34·98	1·14	8·24	·15	·15
379/00	Sohagpore, Central Provinces .	10·91	...	1·37	48·24	32·98	1·54	4·96	·29	·22
283/01	"Yellowish," Cawnpur . .	9·03	·93	4·88	41·05	33·57	4·05	6·49	·93	·78
284/01	"Greenish," Cawnpur . . .	9·06	1·89	4·19	39·83	34·09	3·48	7·46	·67	·51
	5 Good samples, average . .	9·77	...	4·54	46·47	30·58	3·36	5·44	·88	·69
	11 Poor samples, average . .	11·04	...	1·77	45·21	32·38	2·25	7·51	·31	·28

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Guizotia abyssynica, *Cass.*

Syn: G. OLEIFEEA, *DC.*

English: Niger Seed.

Vern: *Kala til, Ramatila, Guji.*

GRAIN.

93/99	Poona	4·88	38·03	19·31	17·47	9·20	6·69	4·42	3·19	3·09
173/95	Lucknow	8·43	38·20	19·25*	11·49	15·19	4·36	3·08	3·08	...
272/94	Poona	6·15	41·14	20·07*	15·08	12·10	4·37	1·09	3·24	...
	3 Samples, average	6·48	39·12	19·31	14·68	12·16	5·14	2·86	3·17	3·09

OIL-CAKE.

166/99	Poona	7·42	9·30	38·56*	25·48	10·03	6·25	2·96	6·17	...

Hordeum vulgare, *Linn.*

English: Barley.

Vern.: *Jao, jau, janb.*

GRAIN.

164/93	"Local white," Cawnpur	13·74	1·80	8·29*	70·32	3·49	1·76	·60	1·33	...
165/93	"Local black," Cawnpur	12·55	1·93	7·73*	69·71	5·63	·85	1·60	1·24	...
4/98	" Cawnpur	11·85	1·84	8·04*	72·65	3·24	1·99	·39	1·29	...

FOOD GRAINS, etc. **Indian Food Grains and Fodders:**

Hordeum vulgare, *Linn.—contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN—*contd.*									
423/00	"Local white," Cawnpur	11·40	1·83	6·62	73·52	4·29	1·72	·62	1·17	1·06
	4 Samples, thick husk, average	12·39	1·85	6·62	71·55	4·16	1·58	·80	1·26	1·06
168/93	"White huskless," Cawnpur	12·18	1·83	7·92*	74·12	2·10	1·00	·85	1·26	...
424/00	" Cawnpore	11·44	1·63	12·50	70·44	1·86	1·95	·18	2·13	2·00
166/93	"Chocolate," Cawnpur	12·79	1·97	8·24*	73·23	1·73	1·89	·15	1·32	...
	3 Samples, thin husk, average	12·14	1·81	9·55	72·60	1·90	1·61	·39	1·57	1·53
	"BHUSA" (straw and chaff from threshing floor).									
444/00	Cawnpur	12·07	1·38	7·81	39·99	24·56	9·19	5·00	1·28	1·25
	GREEN FODDER.									
229/00	Green barley, Panjáb	79·62	·45	2·46	8·20	6·54	2·14	·55	·46	·40
	" Dry state	10·00	1·98	10·85	36·16	28·84	9·44	2·42	2·03	1·76

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Lathyrus sativus, *Linn.*

English : Chickling, Vetch.

Vern. : *Khesari, Lakh, Lang.*

GRAINS.

107/99	Poona	7·89	·79	24·69	57·98	4·28	3·18	1·19	4·21	3·95

"BHUSA" (leaves and pods from the threshing floor).

56/99	Poona	6·10	5·00	9·75	45·39	19·36	9·49	4·91	1·96	1·56
265/99	Poona	11·08	2·93	9·25	43·03	20·57	10·46	2·68	1·66	1·32
	2 Samples, average . . .	8·59	3·96	9·50	44·21	19·97	9·98	3·79	1·81	1·44

Lens esculenta, *Mænch.*

Syn. : ERVUM LENS, *Linn.*; CICER LENS, *Willd.*

English : Lentil.

Vern. : *Masur.*

GRAIN.

103/99	Poona	8·03	1·06	23·00	61·14	2·42	3·54	·81	3·94	3·68

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Linum usitatissimum, *Linn.*

Syn. : L. TRINERVIUM, *Roth.*

English : Linseed.

Vern. : *Alsi, Tisi.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	SEED.									
94/99	Brown *var.*, Poona . . .	4.97	37.47	20.92	26.24	5.60	3.96	.84	3.71	3.35
436/00	„ Cawnpur . . .	6.62	43.16	15.00	26.01	4.94	3.67	.60	2.67	2.40
	2 Samples, average . . .	5.80	40.31	17.96	26.12	5.27	3.81	.72	3.19	2.87

Medicago sativa, *Linn.*

English : Lucerne.

Vern. : *Wilayti-gawuth.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GREEN FODDER.									
51/99	Poona	77.75	.76	3.00	11.89	3.74	2.75	.11	.71	.48
53/99	Poona	78.32	.75	3.81	11.21	3.35	2.44	.12	.81	.61
	2 Samples, average . . .	78.03	.76	3.40	11.55	3.55	2.60	.11	.76	.54
	„ Dry state . . .	10.00	3.11	13.94	47.35	14.55	10.66	.45	3.11	2.21

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Melilotus parviflora, *Desf.*

Syn.: TRIFOLIUM INDICUM, *Linn.*

Vern.: *Sinji.*

GREEN FODDER.

231/00	Panjáb	84·40	·36	2·69	6·16	4·13	1·87	·39	5·15	·428
	Dry state	10·00	2·08	15·52	35·54	23·83	10·79	2·25	2·97	2·47

Oryza sativa, *Linn.*

English: Paddy, Undecorticated Rice.

Vern.: *Dhan, Dangar, Bhát.*

GRAIN—*Undecorticated Paddy.*

	Fine sorts.									
198/00	Patcha Bhoga Paddy, Ganjam, Madras	12·87	2·38	7·07	64·06	7·21	1·39	5·02	1·18	1·13
206/00	Chandan Chur Paddy, Dinajpur, Bengal	11·72	2·25	5·82	66·83	7·78	1·30	4·30	1·08	·93
218/00	Sufeda Paddy, Jallalabad, Panjáb .	12·73	1·88	6·44	64·47	8·29	1·35	4·84	1·05	1·03
457/00	Panekekoa, Long-stemmed Paddy, Assam Valley	12·87	2·05	6·06	65·81	8·07	1·54	3·60	1·07	·97
	4 Samples, average . . .	12·55	2·14	6·35	65·29	7·84	1·39	4·44	1·09	1·01
	Coarse sorts.									
274/00	Rosangi Paddy, Godavari, Madras	11·85	2·25	4·82	65·66	9·28	1·57	4·57	·97	·77

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FOOD GRAINS, etc. Indian Food Grains and Fodders:

Oryza sativa, *Linn.—contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN—*Undecorticated Paddy*—contd.									
	Coarse sorts—contd.									
212/00	Bhogantara Paddy, Backergunj, Bengal	13·82	2·04	6·00	62·16	9·64	1·13	5·21	1·03	·96
226/00	Khasira Paddy, Amritsar, Panjáb	12·64	2·08	5·44	65·84	7·90	1·45	4·65	·95	·87
459/00	Ranga Ahu Paddy, Assam	12·92	1·78	7·38	63·42	8·20	1·50	4·80	1·28	1·18
	4 Samples, average	12·81	2·04	5·91	64·27	8·75	1·41	4·81	1·06	·94
	Decorticated Rice.									
	Fine sorts.									
171/00	Daluva, Ganjam, Madras	11·51	1·03	6·69	78·50	·27	·70	1·30	1·15	1·07
36/00	Fine Winter, Bengal	12·46	·94	6·38	79·25	·18	·69	·10	1·33	1·02
144/00	Basmati of Kandi, Gurdaspur, Panjáb	11·28	·80	5·50	80·81	·23	·83	·55	1·04	·88
458/00	Panikekoa, Assam Valley	13·75	·91	7·25	76·77	·18	1·05	·09	1·25	1·16
	4 Samples, average	12·25	·92	6·45	78·83	·21	·82	·51	1·19	1·03
	Coarse sorts.									
172/00	Coarse Paddy, Ganjam, Madras	11·56	·59	6·13	79·98	·36	·81	·57	1·06	·98
38/00	Coarse Winter, Burdwan, Bengal	12·17	1·26	6·44	78·46	·23	·95	·69	1·06	1·03

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146/00	Jhona, Gurdaspur, Panjáb	10·90	1·04	5·75	80·15	·58	·84	·74	·93	·92
460/00	Ranga Ahu, Assam Valley	13·78	1·23	9·32	73·35	·62	1·54	·16	1·54	1·49
	4 Samples, average	12·10	1·03	6·91	77·99	·45	1·03	·54	1·15	1·10
	Paddy Husks.									
36/00	Fine Winter Paddy, Bengal	9·23	5·43	4·81	40·15	22·14	2·73	15·41	1·06	·77
38/00	Coarse Winter Paddy, Burdwan, Bengal	6·73	3·04	4·12	34·32	25·31	2·57	23·91	·74	·66
144/00	Basmati of Kandi, Gurdaspur, Punjab	7·67	3·59	4·06	40·95	25·04	3·30	15·39	·66	·65
546/00	Rosangi Paddy Husks, Godaveri, Madras	8·76	1·24	4·19	30·86	32·12	2·14	20·69	·75	·67
547/00	Tellavari Paddy Husks, Godaveri, Madras	8·77	2·47	4·82	34·77	29·08	2·56	17·53	·85	·77
548/00	Daluna Paddy Husks, Godaveri, Madras	8·56	1·38	3·13	33·54	29·67	2·48	21·24	·53	·49
549/00	Daluna Paddy Husks, after boiling	9·59	1·39	3·32	33·89	29·96	2·12	19·73	·59	·53
565/00	Paddy Husks, Madras	9·32	1·80	2·32	29·56	40·58	1·35	15·07	·48	·37
	8 Samples, average	8·58	2·54	3·85	34·75	29·24	2·41	18·62	·71	·61
	Rice Bran.									
566/00	Rice Bran, mixed with Husks, Madras	7·98	7·06	5·50	32·98	27·44	3·40	15·66	1·01	·88
567/00	Rice Bran, Madras	8·44	9·56	5·94	35·53	22·91	3·71	13·91	1·06	·95
	2 Samples, average	8·21	8·31	5·72	34·25	25·18	3·55	14·79	1·03	·91

F. 669-74.

Oryza sativa, *Linn.*—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	Paddy Straw.									
37/00	Fine Winter Paddy, Bengal	9·46	·95	1·81	40·54	30·30	6·23	10·71	·33	·29
39/00	Coarse Winter, Bengal	9·51	1·25	2·25	40·89	30·64	5·01	10·45	·38	·36
209/00	Katari Bhog, Dinajpur, Bengal	11·14	1·08	3·19	39·95	28·64	3·47	12·53	·59	·51
213/00	Bhogantara, Backerganj, Bengal	11·10	1·03	2·13	36·78	35·28	2·72	10·96	·45	·34
180/00	Atragada, Rajamundry, Madras	9·23	1·19	1·94	42·95	27·76	2·58	14·26	·32	·31
202/00	Kohala, Rajamundry, Madras	12·04	1·79	3·54	42·80	24·08	2·81	12·89	·72	·57
199/00	Patcha Bhogo, Rajamundry, Madras	9·08	1·34	3·19	39·29	29·74	3·19	14·17	·53	·51
	7 Samples, average	10·22	1·23	2·56	40·46	29·49	3·71	12·28	·47	·41

Panicum frumentaceum, *Roxb.*

Vern.: *Sawan, Bavto, Bunti.*

	Grain.									
80/99	Poona	7·72	4·39	7·06	67·56	7·44	1·70	4·13	1·18	1·13

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Panicum jumentorum, *Pers.*

English: Guinea Grass.

Vern.: *Gini gawat.*

Green Fodder.

50/99	Poona	63·38	·84	1·88	19·36	8·79	2·60	3·15	·41	·30
52/99	Poona	71·55	1·05	2·62	13·71	5·73	1·87	3·47	·53	·42
	2 Samples, average	67·47	·94	2·25	16·53	7·26	2·24	3·31	·47	·36
	Dry state	10·00	2·63	6·23	45·79	20·09	6·20	9·17	1·30	1·00

Panicum miliaceum, *Linn.*

Syn.: P. MILIUM, *Pers.*

Vern.: *Sava, Varagu, China.*

Grain.

97/99	Poona	8·57	5·09	9·38	64·21	6·30	2·50	3·95	1·52	1·50
45/00	Panjáb	9·99	4·52	7·94	64·13	8·24	1·83	3·35	1·39	1·27
88/99	Poona	7·95	4·11	6·81	67·26	7·63	2·16	4·08	1·18	1·09
	3 Samples, average	8·84	4·57	8·04	65·20	7·39	2·16	3·79	1·36	1·29

F. 669-74.

FOOD GRAINS, etc. Indian Food Grains and Fodders :

F. 669-74.

Papaver somniferum, *Linn.*

English: White Poppy.

Vern.: *Khaskhash, Kashkásh, Dana.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	SEED.									
438/00	Cawnpur	4·07	48·95	17·75	16·99	5·09	6·85	·30	2·97	2·84

Paspalum sanguinale, *Lamk.*

Vern.:

	GRAIN.									
476/00	Raishan, Hill Districts, Assam .	12·28	3·06	10·63	60·03	6·96	2·44	3·60	1·79	1·70

Paspalum scrobiculatum, *Linn.*

Vern.: *Kodon, Kodra.*

	GRAIN.									
85/99	Poona	8·01	3·36	5·81	70·06	8·47	1·34	2·95	1·00	·93

Pennisetum typhoideum, *Rich.*

Syn. : Holchus spicatus, *Linn.*; Panicum spicatum, *Roxb.*

English : Bulrush Millet, Spiked Millet.

Vern. : *Bájra, Kumbu.*

Grain.

81/99	"Mahdodhri," Poona . . .	8·05	5·36	9·88	74·26	·60	1·60	·25	1·72	1·58
84/99	"Bhownuggeri," Poona . .	8·60	5·37	9·37	73·94	·86	1·68	·18	1·58	1·41
91/99	"Awned," Poona . . .	8·09	5·50	10·00	72·99	·62	2·12	·68	1·70	1·60
95/99	"Nadiad," Poona . . .	8·87	5·08	8·62	74·75	·90	1·59	·19	1·47	1·38
96/99	"Local *var.*," Poona . . .	8·96	5·75	8·12	74·11	·93	1·74	·39	1·34	1·30
43/00	Panjáb	10·08	4·93	11·12	71·07	·76	1·64	·40	1·86	1·78
	6 Samples, average . . .	8·77	5·33	9·52	73·52	·78	1·73	·35	1·61	1·51

Phaseolus aconitifolius, *Jacq.*

Vern. : *Moth, Mati Kalai.*

Grain.

105/99	Poona	8·57	1·07	22·50	58·85	4·24	3·99	·76	4·01	3·60
48/00	Panjáb	7·46	·83	20·50	63·55	3·83	3·58	·25	3·75	3·28

F. 669-74.

FOOD GRAINS, etc. — **Indian Food Grains and Fodders:**

Phaseolus aconitifolius—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN.									
480/00	Rim-bai-ja, Assam	13·78	·67	17·00	59·34	5·73	3·43	·05	2·97	2·72
	3 Samples, average	9·94	·86	20·00	60·58	4·60	3·67	·35	3·58	3·20
	GREEN FODDER.									
584/00	Panjáb	74·70	·89	3·20	12·00	4·99	2·95	1·27	·684	·513
	Dry state	10·00	3·16	11·36	42·60	17·71	10·47	4·50	2·43	1·82

Phaseolus Mungo, *Linn.*

Vern. : *Urd, Urud, Mash, Kalai.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN.									
100/99	Poona	8·14	·99	18·50	59·11	4·33	4·51	4·42	3·24	2·96
50/00	Green *var.* Mahan, Panjáb	11·05	·96	20·13	60·82	3·48	3·17	·39	3·51	3·22
51/00	Black Mahan, Panjáb	9·69	1·13	22·81	59·36	3·27	3·54	·20	3·75	3·65
185/00	"Black gram," Rajamundry, Madras	9·77	·82	21·81	59·64	3·77	3·24	·75	3·77	3·49
416/00	Cawnpur	10·18	·83	20·63	61·98	3·20	3·13	·05	3·61	3·30

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470/00	"Mati mah," Assam . . .	10·99	·83	20·50	59·03	4·79	3·58	·30	3·64	3·28
	6 Samples, average . . .	9·97	·93	20·73	59·99	3·81	3·53	1·02	3·59	3·33
	Bhusa (leaves and pods from the threshing floor).									
186/00	"Black gram bhusa," Rajamundry, Madras . . .	15·96	1·70	11·19	39·14	17·08	9·97	4·96	2·03	1·79

Phaseolus Mungo, *var.* radiatus, *Linn.*

Vern.: *Mung, Mug.*

	Grain.									
104/99	Poona	9·48	1·83	23·56	56·39	4·42	4·02	·30	4·03	3·77
49/00	Mung, Panjáb	10·02	·93	22·94	58·94	3·38	3·74	·05	3·76	3·67
187/00	"Pessara," Godavari, Madras .	11·64	·79	20·82	58·72	4·04	3·99	·90	4·17	3·33
200/00	Muggo, Ganjam, Madras . .	9·79	·86	20·12	61·67	3·71	3·52	·33	3·75	3·22
417/00	Cawnpur	11·00	·96	18·69	62·19	3·43	3·22	·51	3·41	2·99
	5 Samples, average . . .	10·38	1·07	21·22	59·58	3·80	3·70	·42	3·82	3·40
	Bhusa (pods and leaves from the threshing floor).									
188/00	"Green gram bhusa," Rajamundry, Madras	13·30	2·52	10·88	40·35	18·66	10·38	3·91	1·85	1·74

Pisum arvense, *Linn.*

English : Grey or Field Pea.

Vern. :

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN.									
428/00	Cawnpur	10·56	·93	20·12	61·34	4·46	2·54	·05	3·45	3·22

Pisum sativum, *Linn.*

English. : Garden Pea.

Vern. : *Bara Mutter, Vatane, Watana.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GRAIN.									
180/93	. . . . .	12·05	1·27	24·12*	54·44	5·47	2·65	...	3·84	...
99/99	Vatane, Poona	7·89	1·40	20·06	62·12	5·69	2·79	·05	3·38	3·21
429/00	„ Cawnpur	11·42	1·17	21·00	57·84	5·43	3·05	·09	3·87	3·36
637/00	„ Jabalpur, Central Provinces.	11·05	1·06	19·00	61·86	3·26	2·99	·78	3·31	3·04
	3 Samples, average . . .	10·12	1·21	20·02	60·61	4·79	2·94	·31	3·52	3·20

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BHUSA (pods and leaves from the threshing floor).

58/99	Poona	7·27	3·02	11·75	42·43	19·36	9·65	6·52	2·49	1·88
206/94	„	9·88	...	9·94	42·83	22·27	9·35	5·73	...	1·59
	2 Samples, average	8·57	3·02	10·84	42·63	20·81	9·50	6·12	2·49	1·73

Ricinus communis, *Linn.*

English: Castor Oil Plant.

Vern.: *Arundi, Deweli.*

SEED.

430/00	Large *var.*, Cawnpur	6·43	45·28	14·00	10·59	19·58	2·94	·18	2·36	2·24

Sesamum indicum, *DC.*

Syn: S. ORIENTALE, *Linn.*

English: Gingelly, Til.

Vern.: *Til, Gingili.*

SEED.

86/97	White *var.*, Ahmednagar	4·87	48·13	22·50*	14·05	4·49	5·59	·37	3·60	..
98/99	White *var.*, Poona	4·21	51·96	18·06	14·62	4·49	6·28	·38	2·99	2·89
55/00	White *var.*, Panjáb	5·53	48·53	21·37	13·96	3·56	6·56	·49	3·68	3·42

F. 669-74.

Sesamum indicum—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	SEED.									
432/00	White *var.*, Cawnpur	4·91	48·00	19·69	15·60	5·15	6·32	·33	3·36	3·15
433/00	White *var.*, Bhadala, Cawnpur	4·51	48·45	19·00	16·22	4·33	6·60	·89	3·23	3·04
88/97	Red *var.*, Ahmednagar	5·37	46·20	21·03*	15·87	4·18	6·00	1·35	3·37	...
86/99	Red *var.*, Poona	4·18	49·12	20·37	14·16	2·93	6·65	2·59	3·34	3·26
87/97	Black *var.*, Nadiad	5·42	46·50	25·81*	9·06	6·51	6·03	·66	4·13	...
89/99	Black *var.*, Poona	4·13	47·60	18·12	18·56	4·14	6·85	·59	3·11	2·90
54/00	Black *var.*, Panjáb	5·57	52·27	17·94	13·26	3·87	6·58	·51	3·06	2·87
431/00	Black *var.*, Cawnpur	4·82	47·11	20·00	15·86	5·20	6·34	·67	3·39	3·20
	8 Samples, average	4·73	49·13	19·32	15·28	4·21	6·52	·80	3·27	3·08
	OIL-CAKE.									
169/98	Red *var.*, Poona	10·39	14·12	29·46	29·91	3·88	8·52	3·72	5·81	4·71
170/98	Black *var.*, Poona	10·07	10·90	31·66	29·59	10·30	5·77	1·71	6·15	5·06
	2 Samples, average	10·23	12·51	30·56	29·75	7·09	7·14	2·71	5·98	4·88

F. 669-74.

Setaria italica, *Beauv.*

Syn.: PANICUM ITALICUM, *Linn.*

English: Italian Millet.

Vern.: *Rala, Kangni.*

	GRAIN.									
78/99	"Rala," Poona	7·75	4·54	10·37	69·19	5·22	1·44	1·49	1·68	1·66
44/00	Kangni, Panjáb	10·11	4·96	10·50	63·81	6·29	1·74	2·59	1·75	1·68
46/00	"Swank," Panjáb	10·25	4·33	10·62	65·37	6·18	2·25	1·00	2·07	1·70
477/00	"U. Rai-Soh," Hill Districts, Assam	11·96	3·46	10·25	62·79	6·23	2·98	2·33	1·72	1·64
	4 Samples, average	10·02	4·32	10·44	65·29	5·98	2·10	1·85	1·80	1·67
	GREEN FODDER.									
585/00	"Kangni," Panjáb	76·79	·54	2·08	10·08	6·37	1·82	2·32	4·81	3·32
	" Dry state	10·00	2·09	8·07	39·11	24·71	7·06	9·00	1·86	1·28

Silage.

208/95	(Air-dry), Nagpur	12·08	...	2·53	40·52	33·95	1·58	9·34	·47	·41
122/01	Maize Silage (fresh state), Nagpur	81·87	·21	·77	9·44	5·50	1·10	1·11	·17	·12
	(Air-dry)	7·66	1·07	3·93	48·02	28·06	5·60	5·66	·90	·63
123/01	Sorghum silage (fresh state), Nagpur	60·52	·65	1·89	21·37	11·29	1·59	2·69	·33	·30
	(Air-dry)	5·72	1·55	4·53	51·10	26·87	3·80	6·43	·79	·72
	Fresh state, average	71·19	·43	1·33	15·40	8·40	1·34	1·90	·25	·21
	Air-dry state, average	8·48	1·31	3·66	46·55	29·63	3·66	7·14	·72	·59

F. 669-74.

Sorghum saccharatum, *Pers.*

Syn. : HOLCHUS SACCHARATUS, *Linn.*

English : American Sugar Sorghum.

Vern. : *Deo-dhan.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	GREEN FODDER.									
18/96	Reaped Green, Nagpur . . .	70·96	...	·81	12·14	12·57	1·23	2·29	·18	·13
20/96	Reaped Ripe, Nagpur . . .	57·15	...	1·22	19·17	18·13	1·29	3·04	·26	·19
	Average fresh state . . .	64·05	...	1·51	15·66	15·35	1·26	2·66	·22	·16
	Dry state	10·00	...	2·53	38·94	38·52	3·26	6·74	·56	·40

Triticum sativum, *Lamk.*

Syn. : T. HYBERNIUM, *Linn.*

English : Wheat.

Vern. : *Gehun.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	WHITE—SOFT.									
420/00	"Mazaffarnagar," Cawnpur, United Provinces . . .	11·58	1·70	8·13	75·22	1·23	2·04	·10	1·38	1·30
421/00	"Kathya," Cawnpore, United Provinces	11·00	1·53	9·25	73·65	1·33	2·99	·25	1·66	1·48

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391/00	"Dudhia," Banka, Bengal . .	16·11	1·75	9·44	68·55	2·35	1·62	·18	1·62	1·53
393/00	"Dudhia," Palamau, Bengal .	14·36	1·91	10·19	65·54	2·61	3·35	2·04	1·76	1·63
488/00	"Dudhia," Barh, Bengal . .	12·69	1·87	9·88	70·34	2·37	2·12	·73	1·75	1·58
497/00	"Dudhia," Patna, Bengal . .	13·86	1·82	10·00	69·44	2·71	2·03	·14	1·73	1·60
505/00	"Dudhia," Gaya, Bengal . .	13·73	1·74	10·63	68·53	2·07	2·22	1·08	1·85	1·70
	7 Samples, average . . .	13·33	1·76	9·74	70·18	2·10	2·34	·64	1·68	1·55
	WHITE—HARD.									
422/00	"Rust proof," Cawnpur, United Provinces	9·94	1·50	9·25	75·96	1·50	1·80	·05	1·57	1·48
	RED—SOFT.									
489/00	"Jamali," Barh, Bengal . .	14·26	1·88	10·69	68·25	2·30	2·15	·47	1·82	1·71
491/00	"Champapuri", Durbungha, Bengal	13·27	2·11	12·69	66·75	2·93	2·06	·19	2·14	2·03
499/00	"Jamali," Patna, Bengal . .	13·85	1·72	10·12	70·36	1·78	2·08	·09	1·74	1·62
507/00	"Jamali," Gaya, Bengal . .	13·40	1·71	8·87	71·69	2·39	1·80	·14	1·55	1·42
513/00	"Champapuri," Gaya, Bengal .	12·77	1·98	11·00	69·27	2·15	2·36	·47	1·89	1·76
543/00	"Jamali," Singhbhum, Bengal .	13·12	1·66	10·88	69·29	2·60	1·84	·61	1·89	1·76
	5 Samples, average . . .	13·44	1·84	10·71	69·33	2·36	2·05	·33	1·84	1·71
	RED—HARD.									
395/00	Gangajali, Rajmahal, Bengal . .	13·78	1·89	9·57	70·25	2·33	1·84	·34	1·77	1·53

F. 669-74.

FOOD GRAINS, etc.

Indian Food Grains and Fodders :

Triticum sativum—*contd.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbo-hydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	RED—HARD—*contd.*									
487/00	Gangajali, Malda, Bengal . .	13·53	1·60	11·88	68·55	2·33	1·90	·23	2·01	1·90
485/00	Kheri, Malda, Bengal . . .	13·52	2·20	10·06	68·76	2·93	2·26	·27	1·73	1·61
490/00	Kheri, Pubna, Bengal . . .	13·32	1·84	12·75	66·54	2·77	2·51	·27	2·16	2·04
515/00	Kheri, Arraria, Bengal . . .	12·83	2·06	10·63	68·92	2·67	2·53	·36	1·83	1·70
516/00	Naubia, Arraria, Bengal . .	12·64	1·21	10·50	70·58	2·67	2·19	·21	1·81	1·68
	6 Samples, average . . .	13·27	1·60	10·90	68·93	2·61	2·20	·28	1·88	1·74
	BRAN.									
129/98	Poona	11·88	4·19	10·90*	58·66	9·37	4·56	·44	1·74	...
1899	Poona	9·10	4·40	14·09*	61·03	6·29	4·82	·27	2·25	...
648/00	Roller Mills, Bombay . . .	13·4	3·07	10·30	56·58	10·83	5·36	·42	1·82	1·65
649/00	Hand "Chaky," Bombay . .	12·96	2·34	16·10	57·40	7·20	3·60	·40	2·78	2·57
	4 Samples, average . . .	11·84	3·50	13·20	58·42	8·42	4·59	·38	2·30	2·11

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"Bhusa" (mainly crushed straw from the threshing floor).

355/95	Gursikran, United Provinces	7·61	...	3·04	35·33	45·93	3·34	4·75	·65	·49
443/00	Cawnpur	9·53	·74	2·44	40·19	35·43	4·47	7·20	·53	·39
498/00	Dudhia *var.*, Patna, Bengal	9·20	·99	3·75	37·98	31·68	4·15	12·25	·71	·60
508/00	Jamali *var.*, Gaya, Bengal	9·13	1·32	3·32	37·17	30·51	4·69	13·86	·59	·53
514/00	Champapuri *var.*, Gaya, Bengal	8·17	1·06	3·38	37·12	30·80	4·36	15·11	·67	·54
517/00	"Naubia" *var.*, Arrarea, Bengal	8·66	·80	2·13	39·81	39·78	3·82	5·60	·37	·34
	6 Samples, average	8·71	·98	3·01	37·93	35·69	4·14	9·79	·58	·48

Green Fodder.

228/00	Panjáb	82·65	·40	1·87	7·56	5·07	1·52	·93	·32	·30
	Dry state	10·00	2·07	9·70	39·24	26·31	7·84	4·83	1·66	1·56

Vigna Catjang, *Endl.*

Syn.: Dolichos Catiang, *Linn.*

English:

Vern.: *Lobia, Chaoli, Rawan.*

Grain.

102/99	Poona	7·26	1·35	20·13	63·30	4·07	3·41	·48	3·68	3·22
52/00	Rawan, Panjáb	10·45	1·42	16·81	65·31	2·33	3·58	·10	2·72	2·69
	2 Samples, average	8·85	1·38	18·47	64·30	3·20	3·50	·29	3·20	2·95

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Zea Mays, *Linn.*

English: Maize, Indian Corn.
Vern.: *Makka, Makai, Bhutta.*

No. of analyses.		Moisture.	Oil.	Albuminoids.	Soluble Carbohydrates.	Woody fibre.	Soluble Mineral Matter.	Sand and Silica.	Total Nitrogen.	Albuminoid Nitrogen.
	Grain.									
40/00	(White), Panjáb	11·83	4·53	8·25	72·03	1·16	1·95	·25	1·42	1·32
41/00	(Orange), Panjáb	11·98	4·49	7·37	72·58	1·03	2·45	·10	1·27	1·18
410/00	Local (yellow), Cawnpur	10·54	4·73	9·38	72·53	1·43	1·34	·05	1·57	1·51
411/00	"Jaunpur" (white), Cawnpur	8·04	5·13	9·32	74·33	1·53	1·60	·05	1·53	1·49
412/00	"King Philip," large red (imported), Cawnpur	10·72	4·22	11·62	70·29	1·46	1·59	·10	1·88	1·86
413/00	"Early American" (large white) (imported), Cawnpur	11·02	4·29	9·57	72·20	1·33	1·39	·20	1·62	1·53
414/00	"Extra early" (large orange) (imported), Cawnpur	10·59	4·69	9·69	71·96	1·43	1·54	·10	1·63	1·56
415/00	"Sweet corn" (large white) (imported), Cawnpur	9·94	6·42	12·07	66·81	2·06	2·25	·45	2·04	1·93
	8 Samples, average	10·58	4·81	9·66	71·59	1·43	1·76	·16	1·62	1·55
	Green Fodder.									
582/00	Panjáb	88·92	·31	1·13	4·65	3·11	1·04	·84	·239	·186
	Dry state	10·00	2·52	9·17	37·76	25·25	8·44	6·82	1·95	1·51

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G. I. C. P. O.—No. 1352 R. & A.—16-9-1903.—2,250.—W. S. D'R

THE

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AGENTS.

In Britain.

Messrs.
E. A. Arnold, 37, Bedford Street, Strand, London, W.C.
Constable & Co., 2, Whitehall Gardens, London, S.W.
Sampson Low, Marston & Co., St. Dunstan's House, Fetter Lane, London, E.C.
P. S. King & Son, 2 & 4, Great Smith Street, London, Westminster, S.W.

Messrs.
Luzac & Co., 46, Great Russel Street, London, W.C.
Kegan Paul, Trench, Trübner & Co., Charing Cross Road, London, W.C.
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Karl W. Hiersemann, Leipzig.
Ernest Leroux, 28, Rue Bonaparte, Paris.
Martinus Nijhoff, The Hague.

In India.

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Newman & Co., Calcutta.
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Radhabai Atmaram Sagoon, Bombay.
D. B. Taraporevala Sons & Co., Bombay.

(Vegetable Product Series, No. 77.)
(Fibres.)

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1903—No. 11.

HIBISCUS CANNABINUS.

(BIMLIPATAM JUTE.)

[*Dictionary of Economic Products, Vol. IV.*, H. 177-93.]

REPORTS UPON BIMLIPATAM JUTE.

By PROFESSOR WYNDHAM R. DUNSTAN, F.R.S., *Director, Imperial Institute, London.*

Flying Seal Series, No. 231. No. $\frac{825}{5}$***, dated Imperial Institute, London, the 6th November 1901.*** FORWARDING LETTER.

From—Sir F. A. Abel, Bart, K.C.B., ***Honorary Secretary and Director,***
To—The Reporter on Economic Products to the Government of India, Indian Museum, Calcutta.

I have the honour to enclose a report by Professor Dunstan on two varieties of fibre said to be derived from India, which are at present on the London market, but are not apparently included among the Indian fibres exhibited in the Indian Section of the Imperial Institute.

Report on two varieties of Indian Jute offered for sale on the London market, by Professor Wyndham R. Dunstan, ***M.A., F.R.S., Sec., C.S., Director of the Scientific and Technical Department of the Imperial Institute.*** FIRST REPORT.

Having received information that a new variety of Indian jute, stated to be superior to the ordinary fibre, had been offered on the London market, I requested the brokers to forward samples for the purpose of chemical examination, so that the material might be compared with other samples of Indian jute which have been examined in this Department. This new variety was stated to be

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superior to Bimlipatam Jute, which commands a good price in the market. Reference to the collections of fibres in the Indian Section of the Imperial Institute showed that they did not include a sample of Bimlipatam Jute, at any rate under that name, nor could I find any general description of the fibre in the literature on this subject. No chemical examination of it appears to have been made. It therefore appeared to me desirable also to obtain information as to the characters of this fibre, which is a commercial article, and the brokers were good enough to furnish samples for this purpose.

I think it important to draw the attention of the Reporter on Economic Products to the characteristics of both these fibres, of which I enclose samples. He will no doubt be able to clear up the botanical origin of these varieties of jute about which little or nothing seems to be known in commercial quarters.

It will be seen from the results of the chemical examination and also from their commercial valuation that these fibres are certainly deserving of attention.

New Indian "Jute" Fibre.

Fibre sold as New Indian jute, origin doubtful.

This fibre was stated by the agents who put it on the market not to be jute but a superior material. The brokers, however, regard it as jute, identical with the Indian variety known as Bimlipatam Jute.

The sample consisted of two hanks which may be designated A and B. A was of a pale buff colour and B of a silvery grey colour distinctly darker than A. Both specimens consisted of a highly lignified fibre and resembled jute very closely in appearance. When chemically examined on the systematic plan adopted here, the following results were obtained:—

	Sample A.	Sample B.
Moisture	12·0	11·3 per cent.
Ash	6·55	0·78 " "
Loss on α Hydrolysis	9·1	9·44 " "
Loss on β Hydrolysis	13·1	14·1 " "
Loss on Acid Purification	2·5	2·1 " "
Loss on Mercerising	7·1	7·8 " "
Gain on Nitration	31·9	38·8 " "
Cellulose	74·6—74·2	75·1—75·6 " "
Length of ultimate fibre	1·3—1·8 m. ms.	

These results show that the fibre very closely resembles jute of superior quality. Several specimens of Indian jute examined in this Department have given similar results. There are, however, one or two Indian plants from which fibre has been obtained resembling

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in character that now under consideration and showing a close affinity to jute. Of these may be mentioned one of the little known sterculiaceous plants Abroma augusta. The fibre derived from this plant is similar in character, but superior to ordinary jute, and its examination in this Department has given results closely resembling those now recorded. The sample of Abroma fibre was, however, of better colour and more silky than the present material.

As far as the results of chemical examination can decide the question, it would appear that the fibre received from the brokers is of excellent quality and probably superior to average samples of jute in durability.

Bimlipatam Jute.

Fibre sold as Bimlipatam jute.

This jute as offered on the London market is inferior in general appearance to ordinary jute and does not appear to be so well cleaned. The commercial material submitted included rough, barky fibre as well as fine fibre and fetched from £11 to £12 12*s*. 6*d*. a ton.

The sample selected for chemical examination was composed partly of fibre of a fawn colour and partly of a brownish grey colour; some hanks being intermediate between these two. An extreme representative of each colour was taken, A fawn coloured, B brownish grey.

The following are the results of the examination:—

	Sample A.	Sample B.
Moisture	10·25	10·9–11·0 per cent.
Ash	1·18	6·3– 8·0 „ „
Loss on α Hydrolysis . . .	9·6	14·2 „ „
Loss on β Hydrolysis . . .	15·9	19·1 „ „
Loss on Acid Purification . .	0·4	7·0 „ „
Loss on Mercerising . . .	16·1	14·9 „ „
Gain on Nitration . . .	15·6	6·5 „ „
Cellulose	74·9	67·6 „ „
Length of ultimate fibre . .	3·2–3·3 m.ms.	

These results show that Bimlipatam Jute is of good quality though inferior to other samples of Indian Jute which have been examined in this Department. It is obviously not identical with the fibre referred to above. It will be seen that the fibres of the Bimlipatam Jute are about twice as long as those of the new material, whilst they are much more susceptible to the action of alkalis and mercerising and the cellulose has different properties, as indicated by the smaller gain on nitration. Comparing the results of the examination of the two hanks A and B, considerable differences are apparent, especially in the numbers representing ash, cellulose, loss

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on hydrolysis and gain on nitration. This discrepancy has, however, been explained by a further examination of the specimen B which turned out to be thinly covered with a fine powder apparently held by some adhesive material. This accounts for the high percentage of ash, chiefly composed of calcium and sodium salts. Since these substances are dissolved in the processes of chemical examination the differences in the numbers of the two samples are accounted for. It was found that when the specimen B is boiled with water it loses no less than 4 per cent. by the removal of soluble substances. It appears therefore that the fibre of brownish grey colour has undergone some special treatment; allowing for this it is clear that specimens A and B are essentially the same fibre.

Since Bimlipatam Jute appears to be in some demand in the English market, it would be worth while to enquire into its origin and mode of preparation with the view of improving its quality and general appearance.

SECOND FORWARDING LETTER.

Flying Seal Series No. 268 No. $\frac{168}{9}$, dated Imperial Institute, London, the 9th July 1903.

From - Professor Wyndham R. Dunstan, M.A., F.R.S., Sec., C.S., *Director*,

To - The Officiating Reporter on Economic Products to the Government of India, Indian Museum, Calcutta.

I have the honour to enclose herewith a second report on the subject of Bimlipatam Jute, from which you will see that the results obtained confirm your identification of this fibre with that derived from **Hibiscus cannabinus.**

From what we can learn of the present position of Bimlipatam Jute in the London market, the question of the production of this fibre in India is deserving of further attention.

SECOND REPORT.

Second Report on Bimlipatam Jute by Professor Wyndham R. Dunstan, M.A., F.R.S., *Director.*

Attention has been called in a previous report (F. S. S., 231, dated 6th November 1901) to the trade which is being done on the London market in Bimlipatam Jute, and the results of an examination of a sample have been already recorded. Owing to the importance of the subject from a commercial point of view, further investigation seemed desirable. The attention of the Reporter on Economic Products to the Government of India was drawn to the matter and information was requested with regard to the botanical origin of the fibre. The Officiating Reporter on Economic Products has replied (No. 1912—69 F. S.) that he has no doubt that the so-called Bimlipatam Jute plant is identical with, or closely allied to, **Hibiscus**

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cannabinus, the fibre of which is prepared on an extensive scale in a factory at Chittavalsa in Vizagapatam, Madras Presidency, and also exported in considerable quantities from Bengal as "Mésta pát."

Fibre sold as Bimlipatam Jute.

A second specimen of Bimlipatam Jute has now been obtained from fibre brokers in London together with an average sample of Calcutta Jute which was sent for comparison. The latter specimen consisted of Naraingunge Jute grown in Eastern Bengal and shipped from Calcutta. The average length of the staple was 8 feet. The sample of Bimlipatam Jute was shipped from Madras; it was of a paler colour than the Calcutta Jute and the average length of the staple was 7 feet.

Valuation.

The brokers reported that the present value of Bimlipatam Jute of average quality on the London Market is not more than £12 10*s.* 0*d.* per ton, but that if the fibre could be delivered regularly of quality equal to the sample submitted, it would command a higher price.

Chemical examination.

The two specimens were submitted to chemical examination, the results of which are given below together with those of the specimen of Bimlipatam Jute previously examined and reported upon. The analyses of other Indian Jutes which have been already examined in the Scientific and Technical Department of the Imperial Institute are appended for comparison.

Specimen.	Moisture per cent.	Ash per cent.	Loss on α Hydrolysis per cent.	Loss on β Hydrolysis per cent.	Loss on mercerising per cent.	Loss on acid purification per cent.	Gain on nitration per cent.	Cellulose per cent.	Length of ultimate fibre.
									M.m.
Naraingunge Jute .	12·0	1·0	9·2	14·3	8·8	2·6	34·6	76·4	1·5—4·0
No. 2 Bimlipatam Jute.	12·5	1·3	11·8	15·1	9·4	1·0	26·5	75·4	1—4
No. 1 Bimlipatam Jute (previously examined.)	10·2	1·2	9·6	15·9	16·1	0·4	15·6	74·9	
Indian Jutes (previously examined.)	...	...	...	...	...	...	...	...	
Experts comment on sample.	...	...	...	...	...	...	...	...	
"Extra fine" . .	9·6	0·7	9·1	13·1	8·5	2·0	36·7	77·7	
"Extra" . .	11·1	1·0	8·5	12·5	10·3	1·9	37·5	79·0	
"Medium" . .	10·4	2·8	11·6	17·5	10·5	1·3	35·7	70·0	
"Low" . .	11·0	0·9	13·2	16·1	9·2	2·6	36·6	71·4	

From these results it appears that the present specimen of Bimlipatam Jute is of somewhat better quality than that previously examined; this is shown specially by the smaller loss which it suffers on mercerising, and the larger increase of weight on nitration. It

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HIBISCUS cannabinus.

Reports upon Bimlipatam Jute.

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seems to be but little inferior to an average specimen of Calcutta Jute, and has the advantage of being paler in colour.

Authentic fibre of *Hibiscus cannabinus.*

In connection with the suggestion of the Officiating Reporter on Economic Products that Bimlipatam Jute is derived from **Hibiscus cannabinus**, an authentic sample of the fibre of this plant (Reg. No. 15146-1) from the Indian Collections of the Imperial Institute has been also examined.

This sample is said to have been obtained from the cultivated plant grown in North Arcot, Madras. In its general external appearance and characters it is indistinguishable from Bimlipatam Jute and has a staple of the same average length (7 feet). It is of good colour and has been carefully prepared. The results of its chemical examination are given in the following table, the figures already quoted for the two specimens of Bimlipatam Jute being added :—

Specimen.	Moisture per cent.	Ash per cent.	Loss on α Hydrolysis per cent.	Loss on β Hydrolysis per cent.	Loss on mercerising per cent.	Loss on acid purification per cent.	Gain on nitration per cent.	Cellulose per cent.	Length of ultimate fibre.
									M, m.
Hibiscus cannabinus.	10·1	2·0	8·8	13·7	9·1	2·5	31·3	74·8	1·5—4
No. 2 Bimlipatam Jute.	12·5	1·3	11·8	15·1	9·4	1·0	26·5	75·4	1—4
Bimlipatam Jute No. 1 (previously examined).	10·2	1·2	9·6	15·9	16·1	0·4	15·6	74·9	

These results show that in composition and properties the two fibres are nearly related and that they both also resemble ordinary jute. The percentage of cellulose is nearly the same in all three specimens and the differences exhibited are probably to be attributed to differences in the age of the fibres and in the methods of preparation employed. Taking these results in conjunction with the external similarity of the fibres, there can be little doubt that Bimlipatam Jute is derived from **Hibiscus cannabinus** and that this fibre is deserving of attention in India.

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G. I. C. P. O.—No. 1791 R. & A.—29-10-1903—2,500—R. B.

THE AGRICULTURAL LEDGER.

1904—No. 2.

AGENTS.

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Messrs.
P. S. King & Son, 2 & 4, Great Smith Street, London, Westminster, S.W.
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B. Alfred Quaritch, 15, Piccadilly, London, E.
Williams and Norgate, Oxford.

Deighton Bell & Co., Cambridge.

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Messrs.
R. Friedländer & Sohn, Carlstrasse, 11, Berlin, N. W.
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Messrs.
Karl W. Hiersemann, Leipzig.
Ernest Leroux, 28, Rue Bonaparte, Paris.
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(Vegetable Product Series, No. 79.)
(Oils and Oilseeds.)

THE AGRICULTURAL LEDGER.

1904—No. 2.

SAPIUM SEBIFERUM.

(THE CHINESE TALLOW TREE.)

[*Dictionary of Economic Products, Vol. VI., Pt. II.*, S. 842-49.]

CHINESE OR VEGETABLE TALLOW.

ITS PREPARATION, USES, AND COMPOSITION.

By DAVID HOOPER, F.C.S.

Sapium sebiferum, *Roxb.; Fl. Br. Ind. V. 470, Ind. Kew., IV., 801;* EUPHORBIACEÆ.

THE CHINESE TALLOW TREE.

Syn :—EXCŒCARIA SEBIFERA, *Muell.*; STILLINGIA SEBIFERA, *Michaux*; S. SINENSIS, *Baill.*; S. SEBIFERA, *Bojer*; CARUMBIUM SEBIFERUM, *Kurz*; CROTON SEBIFERUS, *Linn.*

Vern :—*Pippal-yang*, HIND.; *Mom-china, Chlat-pipal*, BENG.; *Tar-charvi*, UNITED PROVINCES, THE DUN; *Pista*, TRANS INDUS; *Toya-pippali*, SANS.; *Varicou, cay-soi* (seeds) CHINESE; *Huang-yang*, JAPAN; *Arbre à Suif, Porte Suif*, FRENCH; *Chinesischer Talq* (The fat), GERMAN.

Habitat.—In China and Japan the tree is indigenous and is cultivated. In the former country it is found in Kiangsu, Chekiang, Formosa, Fokien, Hupeh, Kwangtung, Hongkong, and Hainan. It is chiefly cultivated in Kiangsu, Nganhwei and Chekiang. In some districts near Hangchau the inhabitants defray all their taxes with its produce. It is cultivated and naturalised in other warm countries as Cochin-China, Martinique, the Soudan, in South Carolina, and other south-eastern States of North America. It is hardy enough to grow anywhere in the middle of Europe and flourishes in the open in the neighbourhood of Perpignan in the South of France. HABITAT

In India it thrives well in the United Provinces and the Panjáb, especially at Paoní, Garhwál, at Ayar Tali, and Hawal Bágh, in Kumaon, and in the Kangra valley.

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SAPIUM sebiferum.

Chinese or Vegetable Tallow: its Preparation,

HABITAT.

Dr. Roxburgh's opinion.

Dr. Roxburgh in *Flora Indica*, Vol. III., p. 693, gives his experience of the cultivation and use of the tree. "It is now very common about Calcutta, where, in the course of a few years, it has become one of the most common trees. It is in flower and fruit most part of the year. In Bengal it is only considered as an ornamental tree; the sebaceous product of its seeds is not of sufficient quantity, nor its qualities so valuable as to render it an object worthy of cultivation. Cocoanut oil is better for the lamp, and it is only during very cold weather that the substance becomes firm; at all other times it is in a thick, brownish, fluid state, and soon becomes rancid. Such is my opinion of the famous vegetable tallow of China."

Dr. Macgowan's experience.

Dr. D. J. Macgowan, in a paper read before the Agricultural and Horticultural Society of India in 1850, opposes Dr. Roxburgh's opinion, and speaks in praise of the tree from his experience of several years' residence in China. He shows that the tree is prized not merely for the tallow, though this product constitutes its chief value. Its leaves are employed as a black dye, its wood being hard and durable, may be easily used for printing blocks and various other articles, and, finally, the refuse of the nut is employed as fuel and manure. The husk which envelopes the kernel and the shell are used as fuel for the furnaces for melting the fat. The residuary tallow cakes are also employed for fuel; they remain ignited the whole day and are in great demand for chafing dishes during the cold weather. The pressed cakes also are much valued as manure especially for tobacco fields.

Introduced into Chota Nagpur.

The Tallow Tree was introduced into Chota Nagpur more than sixty years ago. Col. J. R. Ouseley reported to the Agricultural and Horticultural Society of India in 1849 that the seed of this tree had been sent to him some five or six years ago by Mr. Griffith. He found the cuttings took most rapidly, and he had 50 or 60 trees thriving in his garden, which were about 12 feet high.

Habit of the tree.

The small glabrous tree is from 24 to 30 feet high, with a whitish grey bark. The leaves are green, but they redden before they fall. The flowers are disposed in red terminal spikes, and produce in November and December hard brown, oval capsules, each containing three cells. The seeds are ovate (12 m. m. long) coated with a thick white sebiferous stratum, and having an acrid penetrating taste.

Propagation.

Like other plants of the croton tribe the tree is propagated by layers and cuttings. Dr. Macgowan states that grafting (apparently meaning thereby layering) is performed at the close of March or early in April, when the trees are about three inches in diameter and also when they attain their growth. The *Fragrant Herbal* recommends for trial the practice of an old gardener who preferred making cuttings by breaking the small branches and

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twigs, taking care not to tear or wound the bark. It prefers damp places, and in India luxuriates by the side of streams and in the rich mould of canals. It grows equally well on low alluvial plains, in sandy soils and on the acclivities of mountains. The sandy estuary of Hangchau in China yields few other trees. **HABITAT.**

Rate of growth. Mr. J. S. Gamble reports that the growth of the tree in India is rather fast, 6 months per inch of radius. In China the trees are known to be several hundred years old, and though prostrated, still send forth branches and bear fruit. It is easy to cultivate, and is regarded as a handsome and ornamental tree on any landscape.

The Fats.

The Concrete Fat. The concrete fatty matter which surrounds the seeds serves to make candles and tapers which are white and keep their colour for any length of time. In China this substance is used in place of animal tallow for the manufacture of candles, soap-making, and also in dressing cloth. In candle-making it is mixed with white insect wax in the proportion of three parts of wax to ten parts of the tallow. These candles are especially used in Buddhist ceremonies, as they burn with a clear inodorous flame without smoke. In religious ceremonies no other material is used. Vegetable tallow is imported from China in hard white cakes weighing about 1 cwt. (41 to 50 kilogrammes). In some blocks the exterior is of a reddish colour, while the inside is of a dull white. It is called locally *Pi-yu*.

The Yellow Oil. In addition to the solid fat from the seeds the endosperm or kernel yields about 50 per cent. of a brownish-yellow oil called, *Tin-jow*, *ting-yu* or *tsé-iéow* in Chinese, and is used as a burning oil and also for the preparation of varnishes for umbrellas, etc., on account of its drying properties. It has a place in the Chinese Pharmacopœia, because of its quality of changing grey hair into black and other imaginary virtues. It has emetic properties and acts as a purge.

Method of preparation. The consistence of the fat depends very much upon the method of preparation and the condition of the seeds operated upon. Dr. Porter Smith thus describes the process employed for obtaining the tallow from these seeds in China. The ripe nuts collected in mid-winter are bruised, and the pericarp or shell separated by sifting. They are then steamed in wooden cylinders with numerous holes at the bottom which fit upon kettles or boilers. The tallow is softened by this process, and is separated from the albumen of the seeds by gently beating them with stone mallets, when the tallow is effectually removed by sifting the mass through hot sieves. The tallow still contains the brown testa of the seeds, which is separated by pouring it into a cylinder made up of straw rings laid one on top of the other,

SAPIUM sebiferum.

Chinese or Vegetable Tallow: its Preparation,

THE CONCRETE FAT.

in which it is put into a rude press, and the tallow is squeezed through in a pure state. A picul ($=133\frac{1}{3}$lbs.) of seeds yields from 20 to 30 catties of tallow, or about eight per cent., besides the oil which is obtained from the albumen by grinding, steaming and pressing it subsequently. This fatty substance is of a whitish colour, hard and tasteless, and melts at 104°F. (40°C.).*

Conf. p. 18.

Second method of preparation.

The second is a more simple method adopted in some parts of China where the shells with the coating of tallow and the kernels are bruised in a stone mortar, and the mass is boiled for some time in water, or steam allowed to pass into it. The fat is thus brought to the surface where it floats and is removed as a cake when the water beneath has cooled to the ordinary temperature of the atmosphere.

Third method.

A third method is to extract the pulverised seeds together with their shells with petroleum ether or other solvent. This method is often used in the laboratory and yields a product similar to that prepared by the second method, consisting of the tallow from the outer layer mixed with the thinner oil from the endosperm of the seed.

Pure Vegetable Tallow.

We thus have three kinds of fats from the tallow tree seed depending upon the process employed in separating them. In the first place the sebiferous layer yields the pure vegetable tallow melting at 40°C. and upward. This is hard, brittle, almost colourless, and does not leave a grease stain on paper.

Endosperm Oil.

The endosperm oil, extracted from the seeds after the tallow has been removed by beating, is a light strongly smelling oil, turning a yellowish colour on standing; it has a higher specific gravity and possesses drying properties.

Mixture of Fats.

The mixture of fats obtained from the entire seeds has intermediate constants and properties of the two oils just noticed. It has a softer consistence, melting at about 26°C.—32°C., and is a material which may replace lard for industrial and medicinal purposes. In China it is called *Mouieon*, a mixture of *pi-yu* and *ting-yu*.

Indian made Tallow.

From experiments made in India, and probably owing to the introduction of the endosperm oil in the finished tallow, it has been found that the oil is not hard enough in consistence, and when it has been used in candle-making, it is necessary to dip the candles made of it into wax and so give them a hard external coating. The combustion too of these candles was described as imperfect, and they were said to yield a dim light and a thick smoke.

Experiments in the Panjab.

A large cylindrical mass of tallow, solid, of a pure white colour, and inodorous, was exhibited at the Lahore Exhibition in 1864, and it was hoped then that the tallow tree might become an article of commercial importance in the Panjáb. Since that time, however,

* A figure of the press used in China for expressing the oil from seeds of the tallow tree is shown in *Jour. Agri. Hort. Soc.*, Vol. IV., p. 113.

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interest in it has declined, and for many years few, if any, attempts have been made to utilise the tallow from this source. The labour and expense involved in collecting the seeds and extracting the tallow are said to have been far in excess of the value of the product. EXPERIMENTS IN THE PANJAB.

Enquiries regarding the prospects of a trade in the oil have recently reached the office of the Reporter on Economic Products from the Kangra Valley. Two samples of material were supplied, and these were said to be available in some quantity. One sample consisted of the husked seed, and was a whitish powder. This contained 63·6 per cent. of fat, which was perfectly crystalline and melted at 39°. The fatty acids melted at 51°. A sample of oil made by the Holta Tea Company in the same district melted at 30°C., and the fatty acids melted at 42°C. In these two cases it was evident that the second sample of fat had a larger proportion of the oil than the other. Samples from Kangra.

Chemistry of the Fats.

Samples examined by Lewkowitsch possessed an acid value varying from 7·07 to 7·51. De Negri and Fabris found 2·4, both for commercial fat and fat extracted from the seeds; De Negri and Sbrenlati give 2·2 as the acid value. Acid value.

According to Maskelyne, vegetable tallow consists of palmitin and olein. A confirmation of this statement may be found in the fact that Hehner and Mitchell obtained no stearic acid crystals from a specimen absorbing 22·87 per cent. of iodine. Composition.

The following chemical constants have been obtained from the analyses of various specimens of vegetable tallow as recorded by Lewkowitsch:— Chemical Constants.

Melting Point.	Saponification Value.	Iodine Value.
36·5 to 46	178·7—203·6	22·86—53
mean 41·2	191·1	37·9

The fatty acids afforded the following constants:—

39—57	181·2—208·5	29·2—54·8
mean 48	194·8	42

It might be explained that the presence of endosperm oil lowers the melting point and raises the iodine value of the above quoted figures. With regard to this oil the following constants were ascertained by Hobein:—

Specific gravity	0·945
Saponification value	203·8
Iodine value	145·6

The following report taken from the *Journ. Soc. Chem. Industry*, gives the results of an examination of the seeds by M. Tortelli and R. Ruggeri. L'Orosi (23, 289-297—Chem Centr, 1900, 2 [26],1295). The array of constants however evidently applies to the endosperm oil. Chemistry of the Fats.

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SAPIUM sebiferum.

Chinese or Vegetable Tallow: its Preparation,

CHEMISTRY OF THE FATS. Tortelli and Ruggeri's Analysis.

"The seeds of **Stillingia sebifera** contain 41·2 per cent. of fat, of which 22·0 per cent. occurs as tallow in the capsules, and 19·2 per cent, as oil in the kernels. In the following table are given the constants ascertained by the authors for **Stillingia** oil obtained by cold pressing and by extraction with ether. Specific gravity of the oil, 0·9432 at 15°C., 0·9370 at 27°C., 0·8737 at 100°C.

Saponification number (mgrms KOH)	210·4
Acid value (calculated to oleic acid)	6·15
Hūbl's (Relative) iodine number	160·6
Absolute rise of temperature (Maumené)	136·5°
Relative rise of temperature, compared with water	267°
Solubility of the oil in absolute alcohol	4·89 per 1,000
Refractive index (Zeiss-Wollny) (t=35° C)	75°
Rotatory power (200 mm. tube, t = 16° C)	—18·6°
Solidification point of insoluble fatty acids	12·2° C
Melting point of insoluble fatty acids	14·5° C
Iodine number of insoluble fatty acids	161·9
Iodine number (absolute) of liquid fatty acids	178·1
Saponification number of insoluble fatty acids	214·2
Molecular weight of insoluble fatty acids	274·1
Acid value of acetylated fatty acids	195·6
Saponification number of acetylated fatty acids	224·3
Acetyl value of fatty acids	28·7
Hehner value	94·4
Reichert value (for 5 grms)	0·93
Unsaponifiable matter	1·45 per cent.
Absorption of oxygen	12·20 ,, ,,

In carrying out the Maumené test, Jean's Thermelæometer was used. The oil was diluted with twice its volume of a colourless mineral oil, and a maximum value of 65·5° obtained; that is, an absolute rise of temperature of 3 (65·5-20)=136·5°. For the determination of the iodine values see M. Tortelli and R. Ruggeri. L'Orosi 23, 109-122. Chem. Centr. 1900-2 [10] 598. The drying power of the oil was ascertained by Livache's method. The oil does not appear to give any of the characteristic colour reactions."

Allied to Linseed Oil.

The results of these experiments show that **Stillingia** oil approaches linseed oil in character, but it is distinguished from the latter by its strong specific (lævorotatory) action on polarised light. The peculiar odour is said to be due to propionic acid.

With regard to the actual component parts of vegetable tallow it has been asserted that it consists of tripalmitin or of palmitin and olein. The most recent investigator, J. Klimont, (*Monatsh. p. Chem.*, *1903*, 24. [*6*] *408*) doubting the accepted statements about its composition, has made experiments with the object of isolating the mixed glycerides. The fat used for this purpose was obtained from the

seeds by hot expression. It dissolved completely in ether and hot alcohol, but was less soluble in cold alcohol. It had the following characteristics :—Melting point 36·4, iodine value 27·6, saponification value 203·5, and acid value 14·2.

CHEMISTRY OF THE FATS.

Klimont's Analysis.

After the removal of free fatty acids, the fat was extracted with acetone, and the extract filtered from the crystals that first deposited. The crystals subsequently formed melted at 32·2; and, after recrystallisation, at 29·2. On saponification and liberation of the fatty acids, the substance yielded palmitic acid (m. p. 61·8°) and oleic acid with iodine value 81·3. Its elementary composition, iodine value (29·8), and saponification value (202·6) showed that it consisted of a mixed glyceride, oleo-dipalmitin, $C_3 H_5 (C_{16} H_{31} O_2)_2 C_{18} H_{33} O_2$. The fat also contained a very small amount of a substance of higher melting point, probably tripalmitin.

Admixture suspected.

Lewkowitsch in his "Oils, Fats and Waxes" says that the commercial vegetable tallow represents a harder material than the fat extracted from the seeds by means of solvents, and expresses the opinion that the commercial article consists of a mixture of fats obtained from different species or even different families.* That substances with quite a different nature than those determined by the above constants is placed upon the market as vegetable tallow is shown by an analysis recently made by two Italian chemists C. E. Lay and G. Musciaceo (*Journ. Soc. Chem. Industry*, 1903, p. 1005). The experimenters found a sample of vegetable tallow to be optically inactive and therefore free from Stillingia fat. The other suspicious constants were :—Specific gravity at 15° C ·9816; melting point 52·5°; melting point of fatty acids, 55°; acid value, 22·5; saponification value, 231; Hübl's iodine value, 19; absolute iodine value, 97·04.

An analysis of oil-cake.

Before dismissing the references to the chemistry of the fat of the Chinese Tallow Tree it will be of interest to quote an analysis made of the oil-cake, forwarded lately from the Kangra Valley, and examined in the Economic Laboratory of the Indian Museum :—

Moisture	9·15
Oil	10·86
Albuminoids	13·12
Carbohydrates	21·79
Fibre	41·43
Ash	3·65
	100·00
Nitrogen	2·10
Phosphoric acid	·72
Sand	1·05

* Tankawang fat obtained from Borneo and the Straits Settlements is yielded by species of Shorea and Hopea see E. M. Holmes, *Pharm. Journ.*, 1883, 401, and 1887, 901.

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SAPIUM sebiferum.

Chinese or Vegetable Tallow : its Preparation, etc.

CHEMISTRY OF THE FATS.

Oil-cake.

Compared with castor cake, mustard cake and other poonacs, this material furnishes a poor manure for ordinary crops. It would only be of service to the land in the neighbourhood, and would not pay to export to a distance. It contains elements of plant food which should not be destroyed. The seeds of some species of Sapium are poisonous to fish on account of the presence of an acrid substance resembling saponin. The oil-cake therefore is quite unsuitable for human consumption. As already noticed, it is used in China as fuel, and on account of its slow combustion it is used for chafing dishes in the winter season.

Commerce.

Chinese exports.

The export of vegetable tallow from Wu-chang the next district west of Kiu-Kiang in China, amounted in the year 1889 to 517 tons valued at 12,997 li, or double the exports of 1883 and 1884. Chinkiang, Tientsin and Pekin take most of the tallow exported from this district.

Value.

The price in 1874 was eight Mexican dollars per picul or 5 cents per lb. The thin oil or *ting-yu* sells for 3 cents per lb. A large trade is done in this product in the Straits. During the year 1900, for instance, vegetable tallow imported to the Straits Settlements amounted to 52,533⅓ lbs., valued at 7,034 dollars (Mexican), while exports amounted to 91,900 lbs. valued at 37,948 dollars. About 60 per cent. of these imports came from Japan and the remainder from Burma ; all the exports went to Great Britain.

The exports of vegetable tallow from China were 68,548 piculs in 1895, 20,611 piculs in 1896, 23,490 piculs in 1899, 111,312 piculs in 1901, and 140,680 cwts. in 1902. The price averages 8½ Haikuan taels per picul (Haikuan tael = 2s. 8d.; Picul = 133⅓ lbs). During 1902 a rise of 18 per cent. took place, and 29,000 cwts. more than in 1901 was exported, this is a percentage increase of 274 over the average annual quantity exported during the decade 1892-1901. Short supplies elsewhere are responsible for the price.

The duty on vegetable tallow in Italy as per tariff 309 (*b*) is free ; and tariff 307 shows it to be at the rate of 4 lire per 100 kilos.

Duty.

The United States Customs Board have decided that the white brittle fat of the tallow or wax tree is dutiable as "tallow" at ¾ cent per pound, under paragraph 279 of the Tariff Act. The importers claimed it to be free of duty as "vegetable wax," under paragraph 695. An analysis of the article, however, showed it to be a true fat and not a wax.

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FICUS SPP.

(FRUIT, BARK, ETC.)

[*Dictionary of Economic Products, Vol. III*, **F.** 129-252.]

NOTE ON THE CHEMICAL EXAMINATION OF THE FRUITS

By O. REINHERZ,

Some time Curator, Indian Museum, Calcutta, Industrial Section.

FICUS BENGALENSIS.

Ficus bengalensis, *Linn., Fl. Br. Ind., V., 499; Wight Ic. t. 1989; King in Ann. Boy. Bot. Gard., Calcutta, I., Part I., 18, 19, pl. 13, 81^{c}; Ind. Kew., I., 958.*

THE BANYAN TREE.

Syn.—F. INDICA, *Linn. in part*; UROSTIGMA BENGALENSE, *Gasp.*

Vern.—*Bor, bar, ber, bargat,* HIND.; *Bar, but,* BENG.; *Bai,* KOL.; *Boru,* URIYA; *Bare,* SANTAL; *Ranket,* GARO; *Bot,* ASSAM; *Borhar,* NEPAL; *Kanji,* LEPCHA; *Bor,* MAL (S. P.); *Barelli,* GOND; *Wóra, kurku,* UNITED PROVS.; *Bera, bor, bohir, bohar, bargad* (milky-juice *shir,* the fibres of aerial roots are *rish bargad),* PB.; *Baagat, bar,* PUSHTU; *Phagwari,* HAZARA; *Wur, bur,* SIND; *Wad, vad, war, barghat,* BOMB.; *War, vada,* MAR.; *Ala,* TAM.; *Mari, peddimari (marri),* TEL.; *Ahlada, alada, ala, alava,* KAN.; *Peralu, peralin,* MALAY; *Pyi-nyoung (pa-nyaung* or *pyi-nyaung),* BURM.; *Vata,* SANS.

Habitat.—A large evergreen tree, remarkable for the aerial roots which it throws down from the branches, thus expanding itself without limit. It grows in a semi-wild or cultivated state all over India; it is common in the Sub-Himalayan forests from Assam to Peshawar, the forests of Behar, Chota Nagpur, Orissa, the Circars, Central Provinces, Bombay Presidency, and South India. Like the pipal, this tree is considered sacred and Hindus will not cut it.

The fruits, young leaves, the bark and seeds are frequently eaten by the poorer classes, particularly in famine years.

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FICUS spp.

Note on the Chemical Examination

FICUS BENGALENSIS FRUITING SEASON.

The fruits ripen from March to June according to locality (United Provinces, March-April; Kishengarh, Central India, April-May; Bombay, April-June). From Neemuch, Central India, it is reported that the tree bears fruit twice yearly—in May and December. Each tree yields about 6 maunds (1 maund = 82·3 lbs.), and the quantity that a man can pick up in a day is estimated at 10 seers (1 seer = 2·06 lbs.).

The information which follows has been gleaned from the correspondence conducted in the office of the Reporter on Economic Products to the Government of India.

Where eaten.

Bengal.—The fruits, leaves and bark are reported to be eaten all over the Presidency from Mozufferpur in the north to Balasore on the southern coast, and from the Sonthal Perganas to Palamau. In Purneah the tender leaves and bark are eaten, in Beerbhoom the young leaves; the ripe fruits in Bhagulpur, Manbhum, Ranchi, and Saran districts. In Palamau, Chota Nagpur, the fruits are dried, and ground into flour of which bread is made.

United Provinces.—The outer bark of the trunk is, in the Etawah district, ground up fine and made into bread. This has little sustaining power for the report states that those who use it become more feeble daily. In Bara Banki and also in Unao the fruits ripe or sun-dried are made into flour, cooked, and eaten in the form of cakes. The ripe and unripe fruits are also eaten in the following districts:—Azamgarh, Ghazipur, Hamirpur, Muttra, and Sitapur.

Rajputana and Central India.—The dried fruits are pounded, mixed with flour and made into bread in the States of Banswara, Bhopal, Bhurtpur, Dholpur, Jaipur, Jaora, Kishengarh, Marwar. In Banswara the pounded fruit is mixed with flour in the proportion of 2 : 1. The use of the fruit as food is apt to induce constipation, especially if taken in large quantity. In Ajmere-Merwara the inner bark mixed with flour is made into chappátis and eaten. It is not harmful unless partaken of too liberally when it causes disorder of the stomach. The ripe fruits are eaten in Kotah as well as in Tonk, Jhalawar, Alwar, and Baghelkhand.

In Jaora State and Baghelkhand it is reported that there is no trade in the fruits.

Madras.—In the Bellary district the fruits are occasionally eaten in small quantity by children only. The leaves are used for plates. The seeds, juice, and roots are employed as medicine. The wood it is reported finds no use.

The fruit of **Ficus bengalensis**, the common banyan, is consumed during famine times in various parts of India.

It possesses a thick fibrous skin, but as the consumers do not trouble to remove it, the fruit was analysed in its original condition.

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of the Fruits. (*O. Reinhers.*)

FICUS BENGALENSIS FRUITS, CHEMICAL COMPOSITION.

(1) Composition of a dried specimen of **Ficus bengalensis** (from Perawa)—

Water	11·4
Albuminoids	7·1
Oil	4·0
Carbohydrates	35·2
Fibre	36·8
Ash	5·5
	100·0

(2) A sample of the fresh fruit was gathered in Calcutta.

As the sample was very wet, it was partially dried for analysis. It then contained :

Water	12·9
Albuminoids *	8·1
Oil	6·1
Carbohydrates †	35·5
Fibre	31·0
Ash ‡	6·4

The alcoholic extract contains a glucoside, a trace of acid, but no appreciable quantities of tannin or alkaloid.

The colouring matter is precipitated from its deep purple alkaline solution as a reddish brown deposit which dries to an almost black powder.

FICUS CUNIA.

Ficus Cunia, *Ham., Fl. Br. Ind., V., 523; Wight Ic. t. 669; King in Ann. Roy. Bot. Gard., Calcutta, I., Part II., 101; Ind. Kew., I., 959.*

Syn.—FICUS CONGLOMERATA, *Roxb.*

Vern.—*Khewnau, khuthur, kassa, ghwi khenan, ghui,* HIND.; *Dumbur, jajyadomur,* BENG.; *Riu, ain,* KOL.; *Porok podha,* CHUTIA NAGPUR; *Horpodo,* SANTAL; *Kanhya,* NEPAL; *Sangji,* LEPCHA; *Kanai, palkai, taikrau,* MICHI; *Poroh, perina, teregam,* MAL (S. P.); *Kunia,* KUMAON; *Kathjular, trumbal, karndol, kuri,* PB.; *Porodumer,* KHARWAR; *Ye-kha-ong,* BURM.; *Jonua, sodoi,* MAGH.

Habitat.—This attractive species of the fig tribe occurs in Bengal, Orissa, and the Circars; it is also found in the Sub-Himalayan tract from the Chenab up to 4,000 feet, and in Burma. The fruit ripens in August-October and is eaten (*Atkinson, Econ. Products of the N.-W. P., Part V., 1883, p. 85*). Mr. Innes reports that the fruit

* Containing nitrogen		1·31 per cent.
† Ditto	colouring matter	7·7
‡ Ditto	silica (SiO_2)	0·35
‡ Ditto	phosphoric acid (P_2O_5)	0·53

FICUS spp.	Note on the Chemical Examination

FICUS CUNIA FRUITS, CHEMICAL COMPOSITION.

when ripe is eaten uncooked and is rather sweet. The fruit appears to spring from the roots of the tree. The fruit ripens about July. It is considered most edible and is much sought after by bears *(List of Jungle Products used as Famine Foods, 1896-97, p. 10).*

Bengal.—In the Manbhum district the fruit is cooked with oil and a little salt, and eaten along with rice. Other localities where the fruit is eaten are the Sonthal Perganas and Chota Nagpur (Palamau).

A dried specimen submitted by the Deputy Conservator of Forests, Angul Division, shewed the following composition :—

Water	13·5
Albuminoids*	8·7
Oil	5·7
Carbohydrates†	43·1
Fibre	17·7
Ash‡	11·3
	100·0

The alcoholic extract contains a soluble tannin which gives a green precipitate with ferric chloride.

The colouring matter appears to be identical with that characteristic of the other varieties of **Ficus.**

FICUS GLOMERATA

Ficus glomerata, *Roxb., Fl. Br. Ind., V., 535; King in Ann. Boy. Bot. Gard., Calcutta, I., Part II., 173-174, pl. 218, 219; Ind. Kew., I., 960.*

Syn.—F. CHITTAGONGA, *Miq.*

Vern.—*Gúlar, paroa, lelka, umar, umrái, tue, dimeri,* HIND.; *Jagya dumar, yajna dumbar,* BENG.; *Lowa, lóa,* KOL; *Lowa, loa,* SANTAL; *Dumer,* CHUTIA NAGPUR; *Dimeri,* URIYA; *Dumri,* NEPAL; *Tchongtay,* LEPCHA; *Dumer,* MAL (S. P.); *Thoja,* GOND; *Alawa,* KURKU; *Dumer,* KHARWAR; *Gúlar, panwa, lelka,* UNITED PROVS.; *Kathgúlar, krumbal, rumbal, batbar, palák, kakammal, dadhuri,* PB.; *Ormul,* PUSHTU; *Umbar gular,* C. P.; *Umbar,* BOMB.; *Umbara, atti, rumadi,* MAR.; *Umbar,* GUJ.; *Atti,* TAM.; *Moydi, atti, bodda, paidi, mari, medi,* TEL.; *Kulla-kith, atti mara* (the gum is called *Chandarasa*), KAN.; *Ye-thapan,* BURM.; *Udumbara,* SANS.

Habitat.—This large deciduous tree of the Salt Range and Rajputana extends along the outer Himalaya and Sub-Himalayan tract from Kashmir eastwards to Assam, Khasia Hills and Bengal, Burma,

* Containing nitrogen . . . . 1·40 per cent.
† Ditto colouring matter . . . . . . 9·0
‡ Ditto silica ($Si O_2$) . . . . . . 1·65
‡ Ditto phosphoric acid ($P_2 O_5$) . . . . 1·12

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FICUS GLOMERATA YIELD OF FRUIT.

Central, Western and Southern India. It is said to be one of the best shade trees for coffee. It fruits usually from March to July (*Lisboa*), but the fruits are ripe throughout the year at different times (*Talbot*). In Rohtak, Panjáb, the fruits ripen about the end of May, and in Kishengarh, Central India, from April to July. The leaves, bark and fruit are employed as medicine by native practitioners. The fruit has long been known as a useful famine food. In a good harvest the tree yields about 1½ maunds of fruit (Jaora State). About 12 seers can be collected in a day. It will be seen from the reports below that opinions do not agree as to it possessing deleterious properties.

The following is a summary of reports received from districts where the fruit is eaten :—

Where eaten.

Bengal.—In Bhagulpur the ripe fruits are eaten, also the unripe ones after being boiled. Other districts where people eat the fruits are Dinajpur, Champaran, Gya, Jamtara, Monghyr, Mozufferpur and Ranchi.

United Provinces.—Both bark and fruit are used as food. In Bara Banki the ripe or sun-dried fruit is ground to flour and made into cakes. In Banda and Mirzapur districts the fruit is eaten ripe, also unripe after being boiled. In Fyzabad the dried fruit is pounded, mixed with coarse flour and made into chappátis. In the Muttra and Sitapur, Oudh districts, the fruit is considered constipating. It is eaten raw; a kind of bread being made of the dry pulp. In Lalitpur, Oudh, the bark is pounded and mixed with flour, if possible, before being cooked. In Unao, Oudh, the fruit and bark are prepared as food in various ways, *e.g.*, the unripe fruit is boiled and eaten with salt; it is mixed with flour and made into cakes; the dried fruit pounded and likewise mixed with flour is similarly eaten; while the bark after being cut up fine is dried, pounded, mixed with flour and made into chappátis. Besides the districts named, the fruits are reported to be eaten in Azamgarh, Aligarh, Ghazipur, Hamirpur, Hardoi, Jhansi (effects unhealthy), Fatehpur, and Naini Tal (fruit found in all seasons).

Panjáb.—The use of herbs and barks as famine food is reported to have often caused purging and vomiting. It is even thought that the high death-rate in August 1900 was in part due to the use of such food substitutes (Gurgaon). The tree is generally found by the side of canals and tanks (Rohtak).

Rajputana and Central India.—In Bhopal, Bhurtpur, Jaipur, Jaora, Jhalawar, Karauli, Kishengarh, Kotah, Marwar, the ripe fruits are eaten. In times of scarcity the unripe or dry fruits are pounded and eaten with ordinary flour. In Jaipur and Ajmere-Merwara the bark is dried and

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FICUS GLOMERATA FRUITS, CHEMICAL COMPOSITION.

ground with food-grains. In some cases the flour is mixed with the pounded bark in the proportion of ⅓ flour to ⅔ bark. Reports from the Bhopal Agency, Jaipur, Baghelkhand, and Ajmere-Merwara allude to the harmfulness of these foods. In two other instances, however, the opinion was expressed that they were not injurious.

Madras.—In Bellary the ripe and unripe fruits are regularly eaten. In famine seasons the fruits are ground to powder, which is mixed with *chôlum* (Andropogon Sorghum) or other flour, made into cakes and eaten. The fruit is also eaten in Cuddalore. The unripe fruits are boiled and mixed with salt. Ripe fruits are eaten without preparation. The fruit is generally employed as a vegetable, and as a staple food only during famine. No deleterious effects are said to follow the use of the fruit as reported from other districts.

Water	13·6
Albuminoids*	7·4
Oil	5·6
Carbohydrates†	49·0
Fibre	17·9
Ash‡	6·5

The alcoholic extract contains a trace of soluble tannin which gives a light green precipitate with ferric chloride.

FICUS RELIGIOSA.

Ficus religiosa, *Linn., Fl. Br. Ind., V., 513; Wight Ic. t. 1967; King in Ann. Boy. Bot. Gard., Calcutta, I., 55, 62, pl. 67 A, 84u; Ind., Kew. I., 963.*

THE PEEPUL TREE.

Syn.—F. AFFINIOR, *Griff.*

Vern.—*Pipal*, HIND; *Ashathwa, aswat, asúd, asvattha*, BENG.; *Hesar, pipar*, KOL; *Hesak*, SANTAL; *Jari*, URIYA; *Bor-bur*, CACHAR; *Pipri*, NEPAL; *Hesa-aru*, S. P.; *Ali*, GOND; *Pipri*, KURKU; *Pipal, bhor*, PB.; *Pippal*, PUSHTU; *Piƒur*, SIND; *Jári, pimpal, piplo* (SURAT), BOMB.; *Pimpala*, MAR.; *Pipul*, GUJ.; *Pipla, pipli* (= the *fruit*), C. I.; *Avasa Aswartham*, TAM; *Rái, raiya, ragi, rávi* or *kulla rávi*, TEL.; *Rangi, basri, aráli, arle, haspath, rági, aswalta*, KAN.; *Nyaungbaudi, nyoungbaude*, BURM.; *Aswaththamu, asvattha*, SANS.

Habitat.—A large and well-known tree, usually epiphytic, which occurs in the sub-Himalayan forests from the Panjáb eastward, Bengal, Orissa, the Circars, Central India, Burma. Extensively cultivated in most parts of India. It does not throw down aerial roots

* Containing nitrogen		1·19 per cent.
† Ditto	colouring matter	8·5
‡ Ditto	silica	0·25
‡ Ditto	phosphoric acid	0·91

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FICUS RELIGIOSA FRUITS AS FAMINE FOOD.

like the banian. It is held sacred by the Hindus, and none will destroy it. The tree fruits during the hot months, and sometimes towards the end of the rainy season (Bombay). In Unao, Oudh, and Kishengarh, Central India, the fruits ripen in Chait—15th March-15th April. A tree yields on an average about $1\frac{1}{3}$ maunds of fruit, and in a day a man can collect about 10 seers (Jaora State, Central India). The ripe fruits are eaten. In times of scarcity, the green fruits are pounded with rice or *bajri* and made into cakes, while the tender buds are eaten as vegetables. The dried bark is pounded and bread made from the flour. It is not very nutritive. The fruit which ripens about June is also eaten uncooked. The leaves, bark and fruit are used in native medicine. The particulars which follow regarding the use of the fruit, etc., as a famine food have been gathered from the correspondence conducted by the office of the Reporter on Economic Products to the Government of India.

Bengal.—In Palamau the fruit is dried, ground into flour and made into bread. In Manbhum the leaves are cooked with salt and oil as a pot-herb. The fruits are also reported to be eaten in the following localities: Balasore, Bankura, Beerbhoom, Berhampur, Bhagulpur, Champarun, Contai, Dinajpur, Gaya, Manbhum, Midnapur, Monghyr, Mozufferpur, Ranchi. Pipal leaves are eaten in the districts of Balasore, Bankura, Beerbhoom, Dinajpur, Midnapur, Mozufferpur, Purneah, and the Sonthal Perganas. In the reports mention is made of the bark being eaten in Purneah, and the young buds in Midnapur.

United Provinces.—In Bara Banki district a flour is made out of the ripe or sun-dried fruits. This is cooked and eaten in the form of cakes. The same method is practised in Unao with the addition of ordinary flour. The fruits are reported to be eaten in the following districts:—Azamgarh, Ghazipur, Gorakhpur, and Muttra.

Panjáb.—**Ficus religiosa** fruits are stated to be used as food in Gujerat.

Rajputana and Central India.—The ripe and also the unripe fruits are dried, pounded, and cooked as chappátis—Bhopal, Jaipur, Jaora, Kishengarh, Kotah, Marwar. In Banswara, flour is added in the proportion of 1 : 2. Opinions are conflicting as to whether the use of the fruits is injurious. If eaten in moderation it is very possibly harmless. The leaf buds are eaten as vegetables by hill tribes in the Kishengarh State. Other localities where the fruit is reported to be eaten are Ajmere-Merwara, Alwar, Bhurtpur, Bundi, Dholpur, Perawar (Tonk).

Madras.—In Bellary the fruits are eaten in small quantities by children. It is said to produce diarrhœa. The fruits are consumed

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FICUS spp.

Note on the Chemical Examination of the Fruits.

FICUS RELIGIOSA FRUITS, CHEMICAL COMPOSITION.

only in famine years. No bad effects following their use have been observed in Cuddalore and South Arcot.

The fruit of **Ficus religiosa** was consumed in the Khandul district in the famine of 1877-78. A dried specimen from Bundi was analysed and found to contain :—

Water	9·9
Albuminoids *	7·9
Oil	5·3
Carbohydrates †	34·9
Fibre	33·7
Ash ‡	8·3
	100·0

The general characters of the extracts are the same as those of **Ficus bengalensis.**

Note on the colouring matter of Ficus.

COLOURING MATTER OF THE FRUITS OF FICUS.

The amount of colouring matter was determined as follows:

The oil-free material was first boiled with dilute acid in the usual way to dissolve out starch, mucilage, etc. On subsequent treatment with dilute alkali a very deep coloured solution was obtained. This was acidified with hydrochloric acid and filtered. The colouring matter that remained in solution was neglected owing to the lack of a suitable solvent for it.

The precipitated matter was well washed and weighed, after drying on a tared filter at 100°C. It was afterwards incinerated and the weight of the ash deducted.

The dark brown powder obtained was soluble in ether and in boiling alcohol, almost insoluble in cold water, and quite insoluble in benzene and petroleum ether.

Its melting point was indefinite.

It dissolved with black colouration in strong sulphuric acid. Water precipitated a purple-black substance from the sulphuric acid solution.

Strong nitric acid dissolved it with formation of a clear red solution, from which a yellow precipitate was obtained on addition of water.

* Containing nitrogen . . . . 1·27 per cent.
† Ditto colouring matter . . . . 7·5
‡ { Ditto silica (SiO_2) . . . . 1·85
  { Ditto phosphoric acid (P_2O_5) . . . . . 0·69

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G. I. C. P. O.—233 R. E. P.—23-5-1904—2,500—B. N. D.

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(Wax, animal.)

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INDIAN BEES'-WAX.

(APIS DORSATA, etc.)

(*Dictionary of Economic Products, Vol. I.*, B. 392-415.)

Other DICTIONARY article that may be consulted:

Honey and Bees'-wax, *Vol. IV.*, **H. 341-359.**

AN ACCOUNT OF THE SOURCES, PREPARATION, TRADE AND COMPOSITION OF THE BEES'-WAX OF BRITISH INDIA.

By DAVID HOOPER, F.C.S., F.I.C.

INTRODUCTION.

An enquiry into the subject of Indian bees'-wax was instituted by the Reporter on Economic Products to the Government of India in 1893. The following letter from the Officiating Reporter addressed to the Inspector General of Forests, (No. 339, dated Calcutta, 16th October 1893) will explain the circumstance under which the investigation was undertaken:—

"At the request of the Secretary of State, insect-waxes (*viz.*, bees'-wax and white insect wax) have been included among the products of which detailed collections are to be made, and hand-books written, in connection with the Imperial Institute; and I should be very grateful for any assistance in carrying out the enquiry which can be rendered through the medium of the Forest Department."

After referring to the exports of bees'-wax during the five years 1885-1892, and the countries to which it was exported, the letter continues—

"Bees'-wax is said to be brought to Calcutta from the Sundarbans, Western Bengal, Orissa, Behár, North-Western Provinces, Assam, and

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BEES. **An Account of the Sources, Preparation, Trade and Composition**

INTRODUCTION.

Nepal. The best qualities are reported to come from Orissa, Western Bengal, Sylhet, and Nepal.

"I should be very grateful for specimens, if possible, of the bees (preserved in alcohol) and of wax (about 10 lbs.) from different localities, and for any information which may be obtainable under the following heads:—

1. By whom the combs are collected.
2. Place of collection.
3. Method of collection (*e.g.*, from hollow tree trunks, crevices of rocks, etc.).
4. Abundance of supply.
5. Extent of export of wax.
6. Method of preparation of wax. (In some places the combs raised in villages are said to contain a large quantity of sticks, moss, leaves, etc., which are easily removed by stirring powdered borax with the molten wax.)
7. Price of combs with honey, and of the wax.
8. Whether bees are domesticated."

This letter was circulated by the Inspector General of Forests to the Governments of Madras, Bombay, Bengal, North-Western Provinces and the Panjáb, to the Chief Commissioners of the Central Provinces, Burma, Assam, Coorg, and Ajmir, and to the Chief Officials of Hyderabad, Port Blair, and Baluchistán. The Conservators of Forests in these Provinces were instructed to furnish specimens and information to the Indian Museum. During 1894 and 1895 a ready response was made to the circular by all the Forest Officers concerned, and a considerable amount of information became available on the subject of Indian bees and the economic value of their products.

The present number of the *Agricultural Ledger* is accordingly prepared from official documents in the office of the Reporter on Economic Products, and an opportunity has been taken to make the subject more complete by submitting to chemical examination some of the various samples of bees'-wax collected in different districts and deposited in the Industrial Section of the Indian Museum.

The species of bees described in this report were, when possible, identified by Major A. Alcock, F.R.S., and Mr. E. C. Cotes of the Indian Museum, and this opportunity is taken to thank these officers for their courtesy in this respect.

After describing the peculiarities of the bees, the centres of the wax and honey trade in India are discussed in the following pages, the methods of preparing the wax and its local uses are referred to, and finally a report is made on the character and composition of the various denominations of bees'-wax of the country.

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THE INDIAN HONEY-BEES.

Apis dorsata.

Apis dorsata, *Fabr.*

THE HILL BEE.

Vern.—*Vowra,* HIND.; *Khago, bheer mohury,* BENG.; *Lywai,* ASSAM; *Dangara, dingar, sarang, bhural, mahal,* U. PROV.; *Bhavra, bhor, mohal, bhawura, mahook,* CENTRAL PROV.; *Mahal,* PB., *Age, aghya, agya, bhawar, bhammar, bramuar, konge, konege, ghangal, katámbé, hejjen, togri,* BOMB.; *Tagara, heddajenuhula,* KAN.; *Peddapera, kondaténiga, pedda egalu, perai-egalu,* TEL.; *Periathem, malai teni, perumthene,* TAM.; *Pya gyi,* BURM.; *Bambera,* CINGH. Bees are commonly called *Shahd-ki-makhi* (Hind.), or *modhu makhi* (Bengal), meaning the "honey fly."

This bee is found all over India, but not at great height above sea level. It is said to be found at 2,000 feet or more in Bhután and 3,000 feet in the Shán hills, but may justly be termed a tropical insect indigenous to the plains.

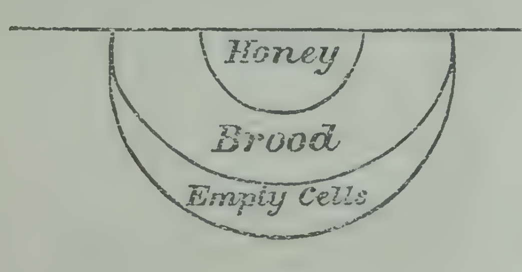
Description.

A. dorsata is the largest Indian honey-bee. It is about one inch long, marked with yellow or light brown stripes, and has thirteen rows of bristles forming the pollen basket. It builds cells to the number of 4½ to the inch. The combs are built exclusively in the open, on the underside of the branches of large trees, in caves or under overhanging rocks, and in old buildings. Dr. Forel says this bee seems to have a great liking for the buildings of old Mogul Emperors, as it is found in the mosques of Fatehpur, Síkri, Secundra and Delhi. It is very partial to the *Semul* tree (**Bombax malabaricum**), *Anjan* (**Terminalia Arjuna**), *Bar* (**T. belerica**), *Pipal* (**Ficus religiosa**) and **Mangifera indica**. In Burma it attaches itself to the *Kanyin* (**Dipterocarpus lævis**), *Thitpok* (**Dalbergia purpurea**) and *Letpan* (**Bombax malabaricum**).

Size of combs.

The combs are three to five feet long and two feet or more deep. The brood comb or lower portion containing the larvæ is about 1¼ inches thick, the upper portion or store comb is much thicker and contains the honey. Some of the combs weigh about half a maund, others are too heavy to be carried by one man. An average comb gives from 10 to 20 lbs. of honey and from 2 to 3 lbs. of wax.

A diagrammatic sketch of the comb of **A. dorsata** is represented below—



THE INDIAN HONEY-BEES.

Apis dorsata.

The reasons against any attempt to cultivate this species in a hive are—(1) The bee builds naturally in the open. (2) It builds normally only one comb, so that the honey cannot be removed without removing the brood also. (3) Although it builds a very large comb, this comb is not so great in cubic capacity, normally as the combs built by a stock of **A. mellifica** which is readily cultivated and the habits of which are well understood. (4) It is only found in a tropical climate, and in this respect differs from **A. mellifica** and **A. indica**, the most productive varieties of which are indigenous to localities having more or less severe winters.

This large bee when disturbed attacks men and animals and it has a reputation of being a vicious insect, but unless disturbed it does not attack, and can be handled by some of the measures usually employed by bee-keepers.

Apis indica.

Apis indica, *Fabr.*

THE TREE BEE.

Vern.—*Satpada,* HIND.; *Mohury,* BENG.; *Aira, doar, khera, door,* U. PROV.; *Doyer,* PB.; *Sadhi, satde, sateri, sative, satar, satree* MAR.; *Kol,* BOMB.; *Sathpuria, satha,* CENTRAL PROV.; *Tudir-jen, tudri-jen, tudabi nona,* KAN.; *Aduku theni, kosumtheni,* TAM.; *Thorrá egalu, pullaténiga,* TEL.; *Pya aung,* BURM.; *Lehej,* ADEN.

Description.

The bees of this species agree with **A mellifica** in having nine rows of bristles to the pollen baskets, and in the division of the anterior wings, relative position of the eyes, in building drone comb, and in the drones being widely different to the workers in shape. In fact, as described by entomologists, they differ from the European honey-bee mainly in size and colour, being smaller and darker. The size is about ½ inch, and with black and brown stripes on the lower half of the body.

This bee builds cells to the number of 5½ to 6 to the linear inch. The Bhutan variety builds larger cells, and more comb, and is not so prone to sting than the varieties met with in the plains. This kind, therefore, has offered advantages to Europeans living in hill-stations to cultivate and hive them successfully. The bee of the plains is considered to be economically worthless for purposes of cultivation.

Habitat.

Apis indica, as distinct from **A. dorsata,** frequently chooses hollow trees to build in where it has necessarily to submit to the presence of other insects. It has even been known to share its dwelling with a nest of wasps. It also builds in empty white-ant hills. Colonel Bingham has remarked that in Burma, where the houses are built chiefly of wood, he had more than once seen a house rendered

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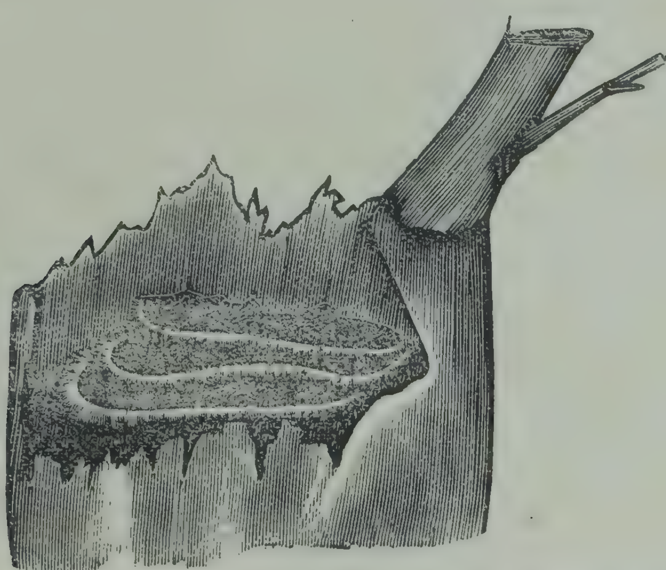
THE INDIAN HONEY-BEES.

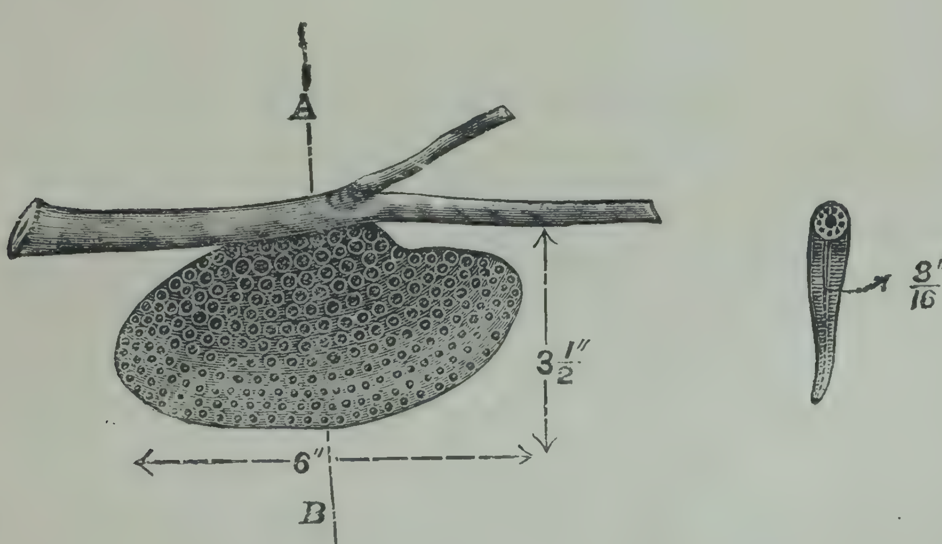
uninhabitable by a swarm of **A. indica** taking possession of the hollows under the wooden stair cases or between the outer walls when these were built.

Apis indica.

In the cold weather these bees build their combs in hollow or decayed trees, and the combs are made in layers, one on top of another, often to the number of seven, hence the vernacular name *Sathpuria* or *Satha*. The appearance of an average specimen of one of these nests is illustrated below :—



In the hot weather the combs are built on the branches of trees, and are of the size of a hand or larger. A sketch of one of these combs from Hoshangábád is given below :—



Among a number of *Sateri* bees collected in Belgaum and sent to Major Alcock for identification, a fly named **Eristalis arvorum**

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was detected. This resembled the bee so closely as to defy detection by a casual observer.

Apis florea.

Apis florea, *Fabr.*

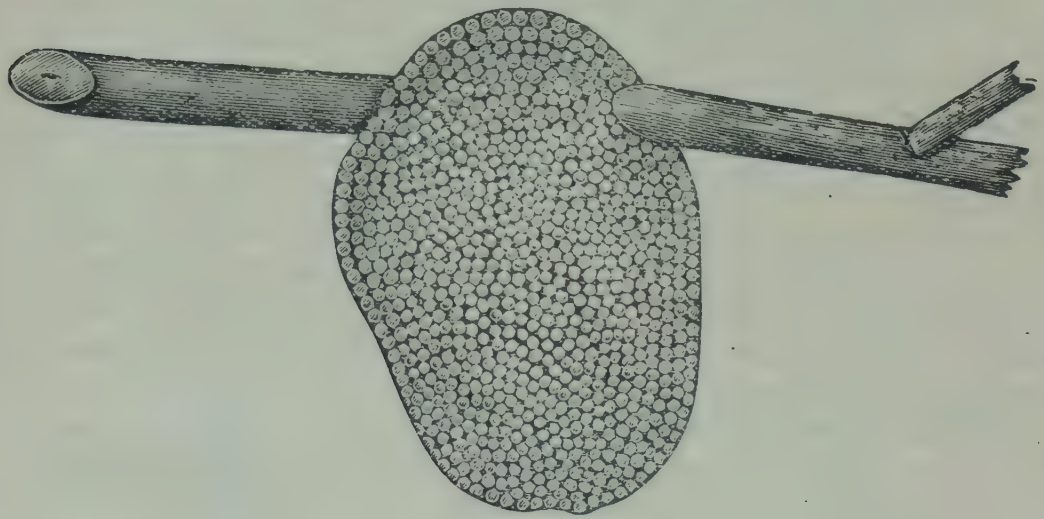
THE FLOWER BEE.

Vern.—*Kátyál*, MAR.; *Sopelia, lamai*, C. P.; *Tudbi, zinya*, BOMB.; *Kol-jen, dubal-jen, kombujenuhula*, KAN.; *Kombuthem, oletheni, shirutheni*, TAM.; *Thodi-pera, pullu egalu, dzuntiteniga*, TEL.; *Cheruténica*, MAL.; *Yin-pya, thit-kaung-byah*, BURM.; *Pushpalit*, SANS.

Description.

This is the smallest species of **Apis** found in India, and is a particularly common bee in the Bombay Presidency. It is very constant in colour, size and shape, being about ¼ inch (8 mm.) in length or somewhat larger than an ordinary house fly. Its worker cells are nine to the inch, and its drone cells about six; the drone is relatively to the worker much larger than the European honey-bee, and has a thick thumb-like projection on the metatarse of the posterior legs. This drone differs also in some other structural respects from that of **A. mellifica.** It is regarded as a stingless bee.

Like **A. dorsata,** this species builds in the open a single comb, and is only found in the plains. Its comb is usually built attached to a branch in the manner shown in the following illustration:—



Habit.

It commonly builds in bushes of a thorny nature, but sometimes under the cornices of houses and inside buildings. The comb is about the size of a duck's egg, at other times it may be as large as a man's hand, or it may be greatly extended and in part duplicated. Another peculiarity about the comb is that it is looped round the bough instead of entirely depending from the lower side as in **A. dorsata.** Near Mandalay combs have been found on bamboos and shrubs of the **Acacia** tribe as *Tanoung* (**Acacia leucophlœa**)

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THE INDIAN HONEY-BEES.

Apis florea.

Cutch (**A. Catechu**), *Nantonkiang* (**A. Farnesiana**), and *Soo-yet* (**A. pennata**). The Morhi bee, probably the species under discussion, is found in desolate forests of West Khandesh, where a bush *Khavi* (**Strobilanthes ciliatus**) grows in abundance. The combs are raised in the shrubs when in flower. The bee is about the size of the common house fly and produces good honey.

A. florea is not nearly so plentiful in Burma as are the other two species. Colonel Bingham has seen very few nests. One was built in a cane bush not more than a few inches from the ground; another under the eaves of the roof of a forest bungalow.

The honey is small in quantity, and that of the small combs built in the open air is commonly very thin, but that found in large sheltered combs is very superior. The honey and wax of this species are not of commercial importance; they are often collected but seldom offered for sale. With regard to the wax it will be noticed that there is a slight variation in the composition of samples, although the average results correspond with the wax of **A. dorsata** and **A. indica**.

THE DAMMAR BEE.

Melipona.

Melipona (Trigona) spp.

Vern:—*Kúnti, kóte, poyé, nasari, pove*, BOMB.; *Bhinkwa, bhumkua, bhungaira*, UNITED PROV.; *Bankua*, PB.; *Misri, misri-jiga, nasri-jen, sollejenuhula*, KAN.; *Kota, kuntali, lokhra*, CENTRAL PROV.; *Nasri theni, kosutteni*, TAM.; *Musuru-téniga, Musari egalu*, TEL.; *Moye byah*, BURM.

Several species of these minute, stingless bees occur in India and Burma. They are about one-eighth of an inch long, and are sometimes called the "Mosquito bee" and "Dammar bee."

They build their combs in the walls of houses, in holes in the ground, and in hollows of trees. The entrance to the hive is generally projecting like the mouth of a bugle made of a soft sticky wax. When the nests are small the wax is not regularly collected, but from large combs the peculiar black sticky wax said to resemble chewed resin or cobbler's wax is used for many purposes.

In the Central Provinces the wax of the *Kota* bee is sold at the low rate of 2 to 4 annas a seer, because it is darker in colour and more sticky than ordinary yellow bees'-wax.

Honey.

The honey of these bees is often tainted with a peculiar odour and bitterish and acid taste, and has a considerable reputation in many parts of India for its medicinal properties. In Nellore the honey is regarded as intoxicating.

Wax.

In Burma the dammar-bees are of some importance in yielding a peculiar resinous wax known as *Pwé-nyet*, and a note by Colonel Bingham on the subject may be read in this connection with some interest.

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BEES. **An Account of the Sources, Preparation, Trade and Composition**

THE DAMMAR BEE. Melipona.

"The dammar-bees, as the species of this genus are sometimes called, are widely spread, being plentiful in South America and in the Oriental region. All the species known to me build their nests in hollows of trees, crevices among rocks, sometimes in holes in stone walls. Horne (*Trans. Zool. Soc.* vii, p. 185) gives an interesting account of the finding of the nest of **Melipona (Trigona) ruficornis**, *Smith*, and states that the hollow in which it was built was coated all over with a layer of black wax, and that the cells, containing a dark honey of excellent flavour, were globular in shape, pendent side by side from the roof. In 'Science Gossip' for 1866, p. 198, the Rev. C. S. P. Parish, then chaplain of Moulmein, gives an excellent description of the nest of **Melipona (Trigona) læviceps**, *Smith*, a fairly common species in Burma. He mentions the extraordinary trumpet-shaped structure of resinous wax, which very often forms the entrance to the nests of the dammar-bees, projecting from the hole in the tree for a foot or more. The resinous product collected and used by the bees in making their nests is called 'Pwé-nyet' by the Burmese, and after boiling in water and mixing with earth-oil or petroleum is largely used for the caulking of boats. The right of collecting 'Pwé-nyet' is sold by the Local Government in Burma and Tenasserim yearly, and forms one of the sources of revenue under 'Minor Forest Products' (*in Blanford, Fauna of Brit. Ind., Hymenoptera*, I. 560).

Pwe-nyet. *Conf. p. 99.*

For further information on Pwé-nyet, Rev. C. S. Parish's "Letter on the tree which produces Pwai-nyet" may be consulted, which will be found in *Journ. Agri. Hort. Soc. of India*, X. 103-105. Proc. 56.

In Trinidad, species of **Trigona** were observed to carry off the rubber fluid from the stems of **Castilloa elastica**, and the gum-resinous exudation of the **Garcinias**, as a sort of ready made wax for their nests. In some cases they actually cut the bark to cause a flow of the desired fluids.

PREPARATION OF WAX.

PREPARATION OF THE WAX.

The preparation of bees'-wax is a very simple operation and requires no skilled labour. In fact, it is almost invariably performed by the jungle tribes who collect the honey and combs from the trees and rocks. The season for making wax is usually the hot weather, and lasts from April to the middle of June.

As we have noticed in an earlier part of the paper the comb consists of two parts, the upper portion containing the honey, and the lower portion bearing the eggs or brood. The upper part affords a clean white wax, while the lower produces a dirty and coloured substance. As a rule the whole of the combs are detached from

the branches and are not separated before being melted. They are first divested of the honey and are squeezed by hand until it is all removed. The comb is then washed in cold water to remove all soluble matter, it is then placed in a brass, iron or earthenware pot or cauldron, half filled with water, and warmed on an open fire. As the wax melts it rises to the surface of the hot water, and the impurities sink to the bottom. The impurities consist of the larvæ, dead insects, twigs, leaves, grass, chips of wood. The pot is then removed from the fire and after being allowed to cool, the wax is taken out and made into cakes or balls. If the wax still contains impurities it is remelted and strained through a piece of coarse cloth or blanket (*kambli*), and the melted wax received in a pan or plate containing cold water.

PREPARATION OF WAX.

Methods of clarifying.

In a few districts some peculiar methods are adopted to purify or clarify the wax. For instance, in Betúl, Central Provinces, the wax is put into a jar of liquid cow-dung for one night, it is then washed and again heated and strained through cloth. This operation is supposed to make the wax very clear. In the Nellore district, Madras, when the melted wax has reached its boiling point, a handful of Tamarind leaves is thrown into the vessel ; this addition is said to precipitate all the foreign matter and furnish a very pure product. Salt is sometimes used in the water in which the wax is boiled, but, as a rule, no chemicals such as borax are employed in the clarifying process.

Artificial colouring.

Then to give the finished wax a golden yellow colour it is mixed with *Haldi* or turmeric, the powdered root of **Curcuma longa.** It is surprising how universally the artificial colouring with turmeric is practised. In Bombay and Madras and throughout Burma this colouring agent is frequently added at the last stage of manufacture.

Bleaching.

The bleaching of wax does not appear to be attempted by the native tribes, although the conditions in India are so suitable. If exposed to the sun in thin layers for a week, most forms of bees'-wax will become completely bleached. White wax is not appreciated in the native markets, so turmeric is employed to improve on the natural pale colour and enhance its commercial value.

Moulding.

Yellow wax is sold in various shapes according to the district. In Nimár and Ganjam it is made into round balls of about half a pound or one pound in weight. The Madras market prefers wax in the form of cakes of one foot in diameter and 1 or $1\frac{1}{2}$ inch in thickness. In the Kurnool district the wax is moulded in blocks of two feet in diameter by 6 to 9 inches in thickness, or the size of a "ten pound wedding cake." The moulds for these cakes are usually pits dug in the ground lined with liquid cow-dung, and are constantly used for this purpose in many districts in Bombay and

PREPARATION OF WAX.

Madras. The largest blocks of wax on the market are those made in the Lower Chindwin Division, Burma, where they are moulded into masses of 8 viss (29·2 lbs.) each.

If for export to Bombay, the collectors in South Kanara strain the melted wax into square wooden boxes. In Burma hollow bamboos are utilized for melting and moulding bees'-wax into cylindrical blocks; either the clarified melted wax is poured into a bamboo joint and allowed to solidify, or, as in the Kátha Division, it is prepared in the bamboo. The Conservator of Forests, Kátha, thus describes the process. A joint of a large bamboo is cut so as to have one end closed. In this a little water is placed, on top of this a thin layer of strips of split bamboo, and wax above this; the whole is then put on the fire. The steam causes the wax to melt and run through the filter and collect at the bottom. When cold, the bamboo is split up, and a mass of pure wax is found in the interior.

Moulding.

Adulteration.

It does not appear that any systematic adulteration is practised by those who prepare bees'-wax for the local Indian markets. In one district in the Panjáb it is said that after cooling the strained wax, one-eighth of its weight of oil of *til* (**Sesamum indicum**) is added before it is made into lumps for the market. The addition of oil would render the wax more plastic and perhaps give it a consistence suitable for local requirements.

Most of the samples collected for the Indian Museum were fairly clean, but a large proportion would have been greatly improved with a second remelting and straining. Very few districts supply refined bees'-wax, and when it is refined by the *banyas* in large towns opportunities are given for adulteration which are occasionally not neglected. In the collection of samples to hand from Indian districts it will be seen that the most flagrantly adulterated bees'-wax comes from Bombay where it is supposed to have been imported from European sources.

CENTRES OF TRADE Bengal.

CENTRES OF TRADE.

BENGAL.—In the Sundarbans, where large quantities of honey and wax are collected through the Forest Department, the combs are taken by a class of Badgis called Moulays or honey-men. Other tribes in Bengal engaged in the trade are the Bharias, Khunjurs and Natuas.

The supply is not large in Singbhum but the industry is capable of great development. It has been estimated that from 3 to 10 maunds of wax could be collected from a range of 150 square miles in this division. It is sold at the rate of 3 to 4 annas per pound by the villagers, while the bazar men sell it for 8 annas per pound or more.

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CENTRES OF TRADE. Bengal.

The amount and value of wax removed by purchasers for the past two years were as follows:—1901-02, 622 maunds valued at R2,510, and in 1902-03, 755 naunds at R3,023. This shows a decided increase, most of the revenue being derived from the reserved forests.

With regard to honey and wax in the Chittagong district, a report on bees of this locality will be found in the *Indian Forester*, Vol. X. (1884), p. 560.

In Bhután, Nepal and Tibet wax is collected on a large scale and brought into Bengal for sale. It is usually obtainable in the cold season when it is sold in the local markets at an average rate of 5 annas per pound. 315 maunds of wax valued at R13,266 were brought from Bhután to Buxár in 1893-94, and was purchased by Marwaris who sent it to Calcutta. This was not an exceptional year, but the figures are quoted to indicate the extent of the trade in this quarter. The price ranges from R30 to R47 per maund for the raw wax which is clarified and boiled down into large circular cakes for export.

Calcutta prices.

With regard to the price of bees'-wax in Calcutta, the Secretary of the Bengal Chamber of Commerce reported in 1896 that this article was comparatively scarce. It commanded a price ranging from R50 to R75 per maund. Pure bees'-wax realized from R65 to R75, and mixed and rough descriptions from R50 to R62 per maund. It is in great request in the Straits and Java.

More recent information on prices of bees'-wax in Calcutta is quoted from the market reports for April 1904: "R53 to R61 for raw wax, R59 to R62 for locally refined. The demand for Europe is very limited. Fair demand for Singapore and the Straits."

Calcutta wax merchants.

The following list of firms selling wax in Calcutta was drawn up by the Secretary of the Bengal Chamber of Commerce in 1896:—

Modhusundum Rampersum Bhobuturum Nundy.
Denonath Mookerjee.
Odhor Narain Roy and Nilmoney Roy.
Madhub Chunder Daw.
Dhun Mudhun Shaw.
Megho Shaw.

The buyers and shippers, and more important dealers are—
Messrs. J. E. D. Ezra & Co., Meyers Bros. & Co., S. Manasseh & Co., Ebrahim Solomon & Co., Cama Ramjee & Co., Goculdoss Hunsraj, Chetram Chutterbhuj.

ASSAM.—Most of the wax of this province comes from the hills beyond the frontier, and very little is produced locally.

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Assam.

Two species of bee are found in Assam, called *Lywai* and *Ngap*. The former is larger than the other and is probably referable to **Apis dorsata.** It builds its hives in inaccessible rocky precipices, and the comb is often half a maund in weight. The *Ngap* or **A. indica** is the smaller bee, not larger than the ordinary house fly, and exists in the jungle.

In the neighbourhood of Cherrapunji, the Khasia villagers (*Wár*) collect honey and wax. Bees are domesticated to a small extent on these hills, and in other places the *Ngap* bee is hived by building a frame in the hollow of a tree trunk about 3½ feet in circumference, and encouraging a swarm.

Sylhet.

Merchants from Sylhet purchase all the wax from the Khasia Hills, but statistics of annual exports are not available. The wax is only of fair quality, and some consignments are of such low value that they realize only 2 annas per pound.

United Provinces.

UNITED PROVINCES.—The right of collecting honey and wax in these provinces is leased annually by auction sale to contractors. There is no particular class of men who make the collection a profession, but those having an inclination and skill in the work take it up as a livelihood. About 50 years ago much honey was collected and brought for sale especially at Petwaghar, Kumaon; the wax was also an article of trade. In the Dehra Dun Division collectors come from Sahâranpur. In the neighbouring Kheri Division wax is collected by Kùchbandhias, Nutts and Pásís; the first two castes are rope-makers, and the last chowkidars and small cultivators.

Dehra Dun.

Formerly the honey and wax used to be collected from all the forests of the Dun Division, but of late the work has been confined to those in the Eastern Dun. The receipts from this source have also declined in recent years which shows that the supply is not so abundant. One of the causes of the decline in trade is the prohibition to carry torches or light fires in fire-protected areas. The export of wax consequently does not amount to more than a few maunds, the selling price of which is 8 annas per pound.

Kheri.

In the Kheri Division honey and wax are gathered in the forests near running streams. Two men are needed to collect; one enveloped in a blanket climbs the tree to which the comb of the Sarang bee (**Apis dorsata**) is attached, provided with a knife and an earthen pot. The other man, also wrapped in a blanket, ignites a bundle of grass and leaves and passes it to the man on the tree who smokes the bees away from the comb, cuts it from the branch, and places it in the pot. The average revenue from the honey and wax contracts in Kheri for five years ending 1893 was R1,392. The average price of wax is 8 annas per pound, and it is supposed that the contractors make at least 50 per cent. profit.

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CENTRES OF TRADE. United Provinces.

In Sahāranpur yellow bees'-wax from the comb of the **A. dorsata** is sold at 11 annas per pound, the annual trade amounts to several thousand rupees. A white wax imported from Bombay is sold in small quantities at 9 annas per pound.

Central Provinces.

CENTRAL PROVINCES.—The Commissioner of Settlements and Agriculture writing in 1896 says:—"The honey and wax industry is not developed to its full capacity. The minor forests are stated to be capable of yielding at least 500 maunds of honey and 100 maunds of wax a year, but nothing like this quantity is collected. In the Chadgarh tract of this district bees are so common that it is impossible to beat for wild animals in the forest."

Nimar.

As in other provinces, jungle tribes extract the produce from these forests and prepare honey and wax for local consumption and export. In Nimár the wild tribes, Bhíls, Kúrkús, Dhanuks, and Náháls are the collectors. In some of the reserves no honey is collected although the supply is abundant. Ratgarh hill is described in the Administration Report as "a perfect hive of bees' nests." The bees identified in this district were the large kind (**Apis dorsata**), and a small kind living in hollow trunks of trees (**A. florea**).

Hoshangabad.

About 50 or 60 years ago the collection of honey in Hoshangábád was solely in the hands of the Gonds and Náháls, but lately some enterprising Mahomedans have taken to it as a means of support. The first man who learnt the art and taught it to his co-religionists was a camel driver attached to a European officer's camp. The Mahomedan collectors, being less inured to jungle life, attack the bee-hives in the day time, being afraid of the reptiles and wild beasts that inhabit the forests at night. The Gond collector of honey, called a Bharia or Mavasi, invests his calling with an air of mystery by observing dietary rules before attacking the comb. It requires five or six persons to accomplish the perilous task of removing the combs from lofty and precipitous crags. The most courageous is he who with a smoking torch in his arm-pit has to climb a lofty tree or rock, or suspend himself in the air in a net or basket with the aid of two ropes—one tied round his chest and the other held in the hand for support—in order to ransack the well-guarded hives, and cut away the best portions. The torch is made of a few dry sticks of wood and green leaves, and is called a *taranga* or *bota*. The Náháls, Gonds, and Kúrkús, who work at night, consider the combs to contain more honey on a dark night than when there is a moon. The comb weighs on an average 5 seers and gives ½ seer of wax and 3 seers of honey. The Gonds and Kúrkús occasionally collect honey as food for themselves and families. The Mahomedans who are professional collectors, and numbered 15 in 1894, pay visits to Bhopál where no

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CENTRES OF TRADE. Central Provinces.

restrictions regarding fires exist. In addition to the wax gathered in the district quantities are imported from Nimár and Betúl; on the other hand wax is exported to Bombay and Surát. The trade is, however, limited and the Mahomedans, the largest workers in Hoshangábád, earn only R200 a year.

Betul.

In Betúl the honey and wax is collected by Gonds and Kúrkús, but no reliable statistics can be given regarding the value of the exports. The combs are afforded by the **Apis dorsata** or Bhowar bee, building in large trees as the **Bombax, Terminalia** and Pipal. Fort Bhowargarh is supposed to have taken its name from the fact of these bees building their combs along its precipices. Combs are found all over the district and the supply is abundant.

Chhindwara.

In Chhindwárá there are three honey-producing bees:—(1) *Bhor* (**A. dorsata**); (2) *Maharose*, similar in colour but of smaller size; (3) *Kothie*, a small bee of an ash colour. The combs of the two former are collected by experienced Gonds, Kúrkús and Bhurias. The supply of combs is limited and the wax is used locally.

Nagpur.

About 500 lbs. of wax are taken out of the Government forests in the Nagpur-Wardha Division by Gonds, Pardhans and Gooras. The greater portion is consumed locally. One Forest Officer gives his opinion that Wardha is the best district in the Province for honey and wax. **Apis dorsata** and **A. florea** have been sent from Nagpur, their combs are found in trees growing near river banks.

In the Chanda district it is estimated that the total annual yield of these products from Government forests alone amounts to 1,000 seers of honey and 300 seers of wax.

Damoh.

In Damoh, forest products, including wax and honey, are collected by Rowats, Sours, Gonds, Konders, Bhomias, Kheroas, Bherias, Kots and Bhíls. It is estimated that 2,500 to 2,600 combs are gathered annually, and 4 or 5 maunds of wax exported.

Mandla.

There are two seasons for collecting honey in the Mandla district, *viz.*, April and May, and November and December. Baigas and Gonds gather the combs which belong to four bees called Mohras, Kanis, Kuteas, and Bhanwars.

Jabalpur.

Jabalpur district contains very few bees' nests, probably on account of the scarcity of water in the neighbourhood.

Raipur.

In Ráipur, collections of combs are made by Kharwars and Binjhwars, those of **Apis dorsata** and **A. florea** affording the largest quantity of honey and wax.

Sambalpur.

Sambalpur combs are collected by Kols, Konds, and Gonds, wild tribes living in and around the jungle. The principal localities affording honey and wax are the Bamra forest, Rehra Khol, the Gad Laising Zemindary, Ráigarh and Borasamber.

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Central Provinces.

A rough estimate of the outturn of bees'-wax from these places is given in the Annual Report of the Forest Department. Bamra 50, Rehra Khol 40, Gad Laising 20, Ráigarh 40, Borasamber 30, total maunds 180. The wax is not consumed locally but is exported, probably to Cuttack and Calcutta.

The following are the rates for wax about 10 years ago in different districts of the Central Provinces :—

	As.	
Ráipur. White Wax	10	per pound.
Yellow ,, ...	8	,, ,,
Dark coloured	6	,, ,,
Nagpur, Nimár and Chhindwárá . .	4	,, ,,
Hoshangábád	6—10	,, ,,
Sambalpur	12	,, ,,
Betúl	6	,, ,,
N. Circle, about	8	,, ,,
Barra bees'-wax (Apis dorsata) . . .	3—6	,, ,,
Kota bees'-wax (Trigona sp.) . . .	1—2	,, ,,

Panjab.

PANJAB.—In the Hazárá district the domestication of bees seems to be confined to the higher parts of the district, in the valleys of the Kanhar and Siran, where it is practised by the Sayads and their tenants ; the villagers adjoining the forests of the Dungagalli range also capture and domesticate bees.

In the Jhelum, Chamba, Kángra, Kúlu and Bashahr Divisions it is reported that the zamindars themselves are in the habit of keeping bees. It would appear from the figures given below that in Bashahr and Chamba only is the practice carried on to any large extent.

Where collected.

Place of collection.—This is generally in the forests from hollow trees and crevices in rocks. In Hazárá "Swarms are easily captured in spring and removed from hollow trees to the zamindars' houses in bags smeared with honey and paste"—Bee-keeping here is, however, "entirely resorted to for the honey."

In Chamba swarms are obtained by putting "hives made of hollowed logs of some species of **Rhus** in selected spots in the jungles, or by attracting swarms to hollows left in the walls of the houses."

In Kángra the bees are kept in "hives formed of mud and boxes in the walls of the houses, or hives built on the branches of trees."

Much the same is reported from Kúlu, Bashahr and Simla.

Collection.

Method of collection.—Generally the honey and wax is obtained by smoking out the bees which are driven alternately to opposite ends of the hive "whilst combs or parts of the one comb are removed at either end." Occasionally, as in Kángra, zamindars wait till the bees have abandoned a hive in a hollow tree, the branch containing it is then cut down. In Hazárá the operation of removing the honey is

CENTRES OF TRADE.

Panjab.

carried out in November. In Kúlu it is done twice a year in July and October, and this is also the case in Chamba where the seasons are May or June, and September or October.

Trade.

Abundance of supply and extent of export.—Hazárá.—As noted above, bee-keeping is here only carried on for the sake of the honey. There is no trade in wax. It is, however, to a small extent purchased by shop-keepers in the Gallis. Hives contain from 20 to 40 lbs. of honey and 2 to 4 lbs. of wax—It is estimated that not more than 120 lbs. is exported annually to Rawalpindi.

Jhelum.—Wax occurs only in very small quantities; there is no export.

Chamba.—Nearly all the honey which is collected is sold to traders from Kángra and elsewhere, the quantity exported is believed to be about 1,600 cwt. and 100 cwt., for honey and wax respectively.

Kángra.—Apparently 2 or 3 maunds of wax are used locally in forming moulds for brass work, etc., while 6-7 maunds are exported.

Kúlu.—There is no regular trade in the wax, and the zamindars often use it themselves; the export may be taken at between 2 and 3 maunds. The quantity taken from one hive varies from 6 seers downwards.

Bashahr.—The annual outturn of wax from all sources is about 20,000 lbs., and nearly all this is disposed of at the Rampur Fair, and finds its way to the plains.

Simla.—The supply is very limited, there is no regular trade.

Ambála.—Very small supply of honey, and export *nil.* Wax is not prepared and the honey even is not sold.

Multán.—Very small supply and no export.

Fresh honey-comb yields some 5 per cent. of wax and 90 per cent. of honey.

The wax is sometimes obtained by skimming the surface or dipping into the mixture a cold lota. Another description of the method is as follows:—

The honey is first strained through a sieve, the remaining part is then boiled and strained through a cloth when the cleared wax collects on the top of the water, when cooled, it is taken off and formed into pieces weighing 2 lbs.

Prices.

Price.—In Hazárá the gallis wax is sold at 3-5 lbs. per R1.

Jhelum.—Combs are not sold, but pure wax fetches 1 lb. per rupee, or $1\frac{1}{2}$ lb. per R1 when adulterated with fat.

Chamba.—Wax $1\frac{1}{4}$ to $1\frac{1}{2}$ seers per rupee, about 10 annas per pound.

Kángra.—There is no honey sold in this Division. Wax is valued at from $1\frac{1}{2}$ to 2 seers per rupee, or $5\frac{1}{3}$ annas to 4 annas per lb.

Kúlu.—Wax 1 to $1\frac{1}{2}$ seers per rupee, or 6 to 8 annas per pound.

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Bashahr.—4 lbs. per rupee for wax, or 4 annas per pound.

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The bees appear to be domesticated in most hill districts, such as Simla, Bashahr, Kúlu, Kángra, and Hazárá. It, however, appears that in most places the bees are captured in the forest and endeavours have been made to make them remain in the hives prepared for them.

The following information is available regarding the kinds of bees found in the Panjáb :—

Varieties of bee.

In Hazárá a little brown bee (probably a variety of **A. indica**) is the one most commonly domesticated.

In Chamba there are 3 varieties said to be domesticated :—

(*a*) "Paruu" which is the best domesticated variety and gives the best honey.

(*b*) "Dharoou," rather more savage, and honey not quite so good.

(*c*) "Thamoon," very savage, honey moderate, and builds only a conical or cylindrical comb.

In Kángra two kinds of bees are distinguished, "Bhanour" and "Darola." Both are wild. The latter is to a certain extent cultivated by the zamindars in the hill villages; it keeps apparently exclusively to the high hills. The former appears not to be abundant and keeps continually moving, staying on the hills during the hot weather and migrating to the forests in the valley at the commencement of the rains.

Kashmir.

KASHMIR.—The bee of Kashmir (*manchtilr*) is almost domiciled; it is a little smaller than that of Europe, though a little larger than the domesticated bee of Kumaon. Nearly every farmer has provision in his house for hiving these bees, consisting of small hives, often to the number of ten, built in the upper portion of the walls. About the end of September or the beginning of October is the best time for taking the honey, which is used largely in place of sugar for mixing with food or preserving fruits.

Rajputana.

RAJPUTÁNA.—In Ajmere-Merwara combs are collected by the Bhíls who obtain the contract from the Forest Department, paying a certain amount in cash for the honey and a certain amount of wax fixed at the time of the contract. It is collected from Todgarh, Dewari, Ammer, Baojari and Mandlan ranges, often from huge precipices. The supply of wax is not abundant, about 1½ maunds only, of which the contractors take half as the cost of collecting.

Baluchistan.

BALUCHISTÁN.—Efforts to collect samples and information concerning bees and bees'-wax in this province have been fruitless; nothing could be gained in the jurisdiction by the Deputy Conservator of Forests. This statement is substantiated by a note in a recent number of the *Journ. Nat. Hist. Soc. Bombay* (Vol. XV. No. 2360).

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Baluchistan.

Major C. G. Nurse, of Quetta, writes:—"The **Apidæ** are numerous, both in species and individuals, but I have never come across a specimen of the true honey-bee (**Apis**) (in Baluchistán) though three species occur in India."

SIND.—No samples also were received from Sind and Karáchi.

Kuram Valley.

KURAM VALLEY.—Dr. J. E. T. Aitchison remarks:—"In every village near the hills in this country bees are largely kept by the people, honey and wax being important articles of traffic. Honey is used in place of sugar which is very expensive."

Bombay.

BOMBAY.—Visitors to the caves of Elephanta and Salsette are often disturbed by the bees that frequent the roofs of those historic monuments, and those arriving from England early become acquainted with the fact that honey and wax are not wanting in India.

Forest officers in various districts of the Presidency have contributed useful information on the kinds of bees peculiar to the districts and the trade in honey and wax.

Panch Mahals.

Commencing with the Panch Maháls we are informed that three kinds of bees are known in this division; the large or *Bhammar* bee (**Apis dorsata**), the common kind (**A. florea**) building under railway bridges, and the smallest or *Kunti* bee, a species of **Trigona.** The honey and wax are collected over most of the division, but the crop is greatest in the two eastern talukas, Dohad and Jhalod. Wild tribes, such as Bhíls and Náikdás, collect the produce of the bees. Men carry long poles with a bundle of dry grass at one end. After climbing a tree they cover themselves with blankets and kindling the grass, sweep the bees off the comb with it; they then cut off the combs from the branches and lower them to the ground. When nests occur in hollow trees the bees are smoked out and the honey and wax removed by hand. The supply is plentiful, and the gathering of wax forms one of the means of support for the jungle tribes in the hot weather. About 100 maunds or 4,000 lbs. of wax are exported every year, and the value is from R25 to R30 per maund of 40 lbs. The bazar rate is about 10 annas per pound.

West Khandesh.

The forests of West Khandesh produce five kinds of bees of which the Bhawar bee (**A. dorsata**), as usual, is the largest honey and wax producer. The other bees occurring in this division are:—

Kotya (**Trigona**); size of black ants raising combs in the hollows of trees.

Mohri (**A. indica**) found in the hollows of trees and rocks.

Zinya or common bee smaller than cattle flies and harmless; combs contain much honey and a whitish wax.

Sondya, white bees, somewhat larger than ants. They raise combs in small branches of trees and in crevices of the earth,

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Bombay.

and store up honey in the hot season, April and May. The honey is white.

The Sátpúrá ranges, *viz.*, Shirpur, Shahade and Akrain, export wax in abundance, which is brought in for sale by the Bhíls and other wild tribes. The export is about 10 maunds annually. The wax sells locally for 8 annas per pound.

East Khandesh.

In East Khandesh honey and wax are collected by Bhíls, Náháls, Tadvís and other hill tribes inhabiting the Sátpúrás. The products are only sufficient for local consumption and there is no export trade. The three bees known in the division are the *Sadhe* (**A. indica**), *Age* (**A. dorsata**) and the *Koti* bee (**Trigona sp.**).

Sholapur.

Honey and wax are not obtained in large quantity in the Sholápur division on account of the scarcity of trees and wild flowers. The combs are collected by low caste Kunbís, Mahars and Mangs, but wax is not exported.

Satara.

In Sátára combs are collected by fishers (Kolís), shepherds (Dhángars) farmers (Kunbís and Kamoses). A fair supply of honey and wax may be obtained in Jáoli, Mahábleshwar, Patara and Spirada ranges, and in the western part of Sátára and Wái. About four kundis (of 560 lbs.) are exported annually. A single comb will sometimes fill 10 or 15 bottles with honey, and supposing one bottle to be worth three annas, the whole costs R2-8 or R3. Wax is valued at one-quarter the price of the honey.

Ratnagiri.

There are three kinds of bees met with at Ratnágiri which produce only sufficient honey and wax for local requirements. The honey combs are formed by the *Kalambe* or *Aghya* (**A. dorsata**) found in inaccessible rocks or on branches of tall trees; the *Katyal* (**A. florea**) found in small trees or bushes; and the *Poyé* (**Trigona**) lodged in hollow tree trunks or burrows of ant-hills. The honey and wax are collected by Kunbís or the labouring class, as at Kolába, but there is no export of wax from the division. The local price is 4 annas a seer of 28 tolahs.

Kánara, for purposes of Forest administration, is divided into a Northern, Southern, and Central Circle, and in each of these divisions there are large supplies of wax collected and sent to Bombay.

Kanara.

The combs are not gathered in Kánara by any particular class of people, and anyone may collect outside of forest limits. The right to collect honey and wax inside forest limits is farmed out to contractors and sold yearly to the highest bidder. In the Northern Division, the *Konge* bee (**A. dorsata**) supplies large quantities of combs. Expert climbers ascend the trees at night, and with smouldering torches drive off the bees and remove the comb in baskets. The following sums were received in 1894 for collecting comb in the jungles:—Supa

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Bombay.

range, R500; Haliyál range, R75; and Kárwár range, R50. The wax averages R14 per maund, and is principally purchased by Goanese for making wax candles.

Kanara.

In the Central Division, Kánara, the supply of wax is derived chiefly from Yellapur and Mundgod, Yellapur producing 2,250 lbs. and Mundgod 750 lbs., or an annual outturn of about 3,000 lbs. Wax is sold by the collector for R275 to R290 per *kandi* of 560 lbs. and is purchased by Goanese. Inferior portions left by straining are sold at a low price. A peculiar fact has been noticed in this division, that the honey is always at its best when the *Karvi* (**Strobilanthes ciliatus,** *Nees*) is in flower. This interesting fact confirms the belief in the virtue of this tribe of plants in affording a superior food for Indian bees.

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The four talukas of Sirsi, Siddapur, Kumta and Honawar in the Southern Division, Kánara, are largely used by honey and wax contractors. The values of the contracts for three years ending 1893-94 were—

	1891-92.	1892-93.	1893-94.
	R	R	R
Sirsi . . .	1,571	865	1,340
Siddapur . . .	157	122	139
Honawar . . .	48	73	64

The contractor, while keeping a little for local sales, sends most of the wax to Bombay in square wooden boxes. The price is very low, being only 3 or 4 annas a seer of two pounds. There is such a ready sale for the wax that very little trouble is taken to preserve the honey.

Belgaum.

The seasons for collecting wax in Belgaum are May and November. There are four kinds of bees met with in the district, **A. dorsata, A. indica, A. florea** and a **Trigona**; but the bulk of the wax comes from the combs of the **A. dorsata**, which is known by the Marathi name *Konegi*. The combs are collected by the village people, principally Mhars, Kunbís and shepherds, those of the *Konegi* bee are only collected at night, at which time the bees are less inclined to use their stings. The supply of wax in this district is not large, amounting in all to about 50 or 60 maunds (28 lbs. each). Most of the wax is exported to Goa and Bombay; the market price in Belgaum ruling at from R15 to R20 per maund.

Dharwar.

In Dhárwár combs are collected by Lamanis and Hale Paiks, and the wax is made up into balls. The amount collected annually is 60 maunds valued at R10 per maund. It is estimated that R300 worth of wax is annually exported from the division.

Experiments in apiculture have been attempted in the hill-stations of Bombay, but as far as can be ascertained, with no very signal success. The only bee which can be said to be domesticated is the *Nasri-jen* of Kánara (a species of **Trigona**), the honey of which has a peculiar taste and is prized for its medicinal properties.

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Berar.

BERAR.—Reports on the collection of honey and wax in the Hyderabad Assigned Districts have been received from Wún, Básim and Ellichpur through Mr. Cecil Bagshaw, the Conservator of Forests. The abundance of supply depends to a great extent on climatic conditions; a dry season being responsible for a large yield, while a heavy rainfall prevents the formation of combs. The industry is in the hands of the Kúrkús or country people, and the Gonds, Kolams, Banjárás and other wild tribes. The collection of the *Agya* combs (**A. dorsata**) is very troublesome and is only performed at night time. A man clad in a blanket climbs up one of the trees (which are very lofty, such as the *Bar*, *Pipul* or *Anjan*) and, with a torch in his hand, burns and disperses the bees. The collectors usually rub themselves over with some kind of ointment prepared from herbs, the composition of which is known only to the Gonds and Kolams, and is said to be sting-proof.

Trade.

The extent of the export of wax cannot be even approximately given as some is collected in forests belonging to Izardars; moreover, no records are kept, as from certain forest lands, head loads are allowed to be removed free of duty. Pusád Taluk in Básim gives a fair yield, and as much as R1,000 to R1,500 worth is reported to be sold annually in the bazars. Collections are also made in the forests of the Melghát, Ellichpur, and in Mangrúl and Wún, but the exports, if any, are of no commercial importance. The bazar price of wax in Ellichpur is 4 annas per pound which is very low.

The bees from the Wún district have been identified as **Apis dorsata** and **A. florea**; those from the Básim district as **A. dorsata, A. florea** and **Trigona sp.**; and those from Ellichpur as **A. dorsata** (*Agia* bees) and **A. indica** (*Koti* bees).

Madras.

MADRAS.—This Presidency supplies large quantities of wax and honey for local and export purposes at very moderate rates, and in many districts the trade is capable of great expansion. The hilly regions from Ganjam to Tinnevelly on the Eastern Coast, and the Western Gháts of South Kánara and Malabar are the abodes of wild bees of the **Apis** family whose combs are annually gathered by the hill tribes.

In Ganjam and Vizagapatam the Konds recognise four different kinds of bees known by the Uriya names of—

(*a*) *Bhaga mohu*, a large sized bee (**Apis dorsata**).
(*b*) *Sattapuri mohu*, building its comb in 7 layers (**A. indica**).
(*c*) *Binchina mohu*, with a comb like a fan.
(*d*) *Nikiti mohu*, a very small bee.

The honey and wax are collected by the Konds and a class of men called Benias, who almost live in the forest and are expert

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climbers of precipitous rocks and lofty trees. From Gúmsúr from 600 to 700 lbs. of wax are annually exported, and a large quantity in addition is brought down from the hills. The local price is 6 to 7 annas per pound. The estimated annual outturn of wax in Kondasemtha and Kristurdesrepeta is about 800 maunds, which sells at the average rate of R17 per maund.

In the Pálakonda range of Vizagapatam professional honey gatherers belong to the Savaras, Jotoahas and a tribe called Nakkalus.

Godavari.

The Godávari and Kistná districts afford honey and wax more than sufficient in amount for local requirements. It is collected by Gottehs and Kays. Wax is one of the principal products of Peddapuram in Godávari, and in the Kistná district it is procured from Satterapalle, Palnád, Vinukonda and Bundar. A collector in the last named district is let down the rocks with a basket lined with wax, a knife, brushwood and a light. When he reaches a comb he cuts away the underpart containing the larvæ, which can usually be done at night without disturbing the bees; he then lights the brushwood to drive the bees out and cuts off the upper portion of the comb and puts it in the wax-lined basket. At Vinukonda wax sells for R12 the maund of 25 lbs., but there is no great supply as the quantities collected are mostly consumed locally.

Kurnool.

Kurnool.—Large collections of honey and wax are made on the Nellamalái Hills in Kurnool. The hillmen of the Chenchu tribe are the collectors of these products, and this has been their recognised caste occupation from time immemorial. It is strange that this class of people, otherwise most cowardly and apathetic, have the courage to venture into these apparently inaccessible and dangerous places. The estimated quantity of wax exported from Sirvel taluk is about 200 maunds, this is brought to the market from Muttanal and Chruvu. In 1894 Sirvel exported 5,000 lbs. of wax valued at 4 annas per pound, and Nandyál 250 lbs. at 8 annas. The whole is sold to Bombay and Madras merchants. Very little honey or wax is collected in the Verramalai Hills.

Bellary.

Bellary affords wax in the Ráyadrug and Sandúr zamindaries. The combs are collected by Boyas and Bedars from Government leased forests, the Raja's forest at Sandúr, and from reserve forests near Ráyadrug. The combs occur in crevices of over-hanging rocks. It has been observed in this district that when the Tamarind tree flowers profusely a large yield of honey is always obtained. About 20 maunds of wax are exported each year from the Ráyadrug reserve, selling at the low price of R3-12 per maund.

Cuddapah.—Wax is collected by the hill tribes, Chenchus and Yánadís, from the combs of the **Apis dorsata** found in crevices

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of cliffs and on the trunks of trees. Men are lowered from the rocks with lighted torches and collect the combs in baskets. 150 maunds of wax are annually exported from this district, and is chiefly sent to the Madras markets where it sells for R15 to R20 per maund. Madras.

The Yánadís and Muthuragus are the expert comb collectors of the Nellore district, and the localities are the Veligondahs (a part of the Eastern Gháts) and to some extent the island of Sriharikota. When the hives are built on precipitous rocks, a drop made partly of bamboo and partly of *Jurvi* (Ficus Tsiela) fibre is let down the cliffs after securing one end of it to a tree or staple. One of the party then descends by the drop, and for his safety a rope is passed under his arms. He carries with him a leather bag, a torch made up of whisks of grass, and a stout stick. On getting in line with the combs he lashes himself to the drop, lights the torch to drive away the bees, and removes the combs, which are handed up to those of the party waiting above the cliffs. Statistics as to the quantity collected are not available, but about 20 maunds or 500 lbs. of wax are annually exported. The price is R3-5-4 per maund which the middlemen sell at the rate of R12 to R16. The bees from this district were thus identified:— Nellore.

Perai Tenai Egalu	.	Apis dorsata.
Thorri Tenai Egalu	.	A. indica.
Pulla Tenai Egalu	.	A. florea.
Mussan Tenai Egalu	.	Trigona sp.

In North Arcot combs are collected by Irulas or Yánadís all over the hill forests. The combs are reached by means of a ladder made of the *Zidda thiga* creeper suspended from the rock; combs are collected chiefly for their wax which is largely exported to Madras, Vellore and Vaniyambádi. The combs are said to yield ½ viss of wax and 1 viss of honey. The wax is sold for 12 annas a viss locally, and in Madras at R2-8 a viss. (1 Viss = 3·65 lbs. Av.) North Arcot.

Honey and wax are collected in the mountainous and thick jungles of Trichinopoly such as those of Pachamálais, the Marnagapuri, the Kolavur hills, and the Musiri range, where wax is obtained in some abundance. Wax is also one of the principal products of the Pachamálai hills. The combs are collected from large trees and from species of Euphorbia. The Catholic missionaries of Trichinopoly have tried to domesticate certain kinds of indigenous bees, but, as far as can be ascertained, with only indifferent results. Trichinopoly.

There is a limited industry in honey and wax in Tinnevelly, where hill-men and coolies collect combs near the foot of the hills. There is no means of knowing the extent of supply as the right to collect is leased out to contractors who extract other minor produce

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from the forests. The price of the wax varies from R14 to R16 per maund. Madura affords limited supplies of honey and wax from the Saduragi and Varshanad hills.

Coimbatore.

Coimbatore is a large centre of the wax trade in South India as the hills on the north, south, and west are the homes of innumerable bees. In South Coimbatore combs are collected by Irulars, Maduvars, and Kaders in the forests of Tunacadavu, Pollachi, Udamalpet, Metupolyam and Bolampati ranges. The collection of the honey combs is a dangerous occupation. A hill man with a torch in his hand and a number of bamboo tubes suspended from his shoulders descends by means of ropes or creepers to the vicinity of the comb. The sight of the torch drives away the bees, and he proceeds to fill the bamboos with the comb, and then ascends to the top of the rock. 200 maunds of wax are collected annually and sells for R7 per maund.

The hill men on the eastern side of Mangapatti domesticate bees to a small extent. The contrivances to hive them are small mud houses a foot square, or earthen chatties or pots placed mouth downwards with a few holes made in the bottom.

In North Coimbatore Sholagars, a wild tribe, collect combs from rocky crevices. These combs are much larger than those found on trees and are supposed to contain twice as much wax in proportion to the honey. Kollegal and Bhavání ranges furnish about 125 maunds of wax a year which is all exported.

Nilgiris.

On the Nilgiri Hills the aboriginal tribes of Todas, Badagas and Karumbas are adepts at collecting and preparing honey and wax for the market. On these hills the combs of **Apis dorsata** are found at an elevation of 5,000 feet, and these combs are collected by Jain Karumbers and Sholagars. The supply of honey varies according to the nature of the season, and is especially plentiful and of good quality when **Strobilanthes Wightianus, S. Kunthianus** and other species are in flower. These plants clothe the hillsides with blossom in certain places once every few years.

Malabar.

In North Malabar combs are collected by Jain (honey) Karumbers in the Kudracote and Begur reserves. The **Apis dorsata**, building on trees, supplies large quantities of wax and honey. About 170 lbs. of wax are collected annually from the above reserves; it is sold at Manantoddy and taken to Tellicherri and Mysore.

The three bees found in South Malabar are—**A. dorsata, A. indica** and **A. florea**. The combs are collected by a wild tribe called Naikers. Sometimes the combs of the first named bee are so large that one cannot be carried by a single person. They are removed from the rocks by night when there is no moon. A man is let down the rock by a rope or rattan, and with a torch in his hand, he drives away the bees. He then removes the combs which are

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South Kanara.

placed in baskets and carried up by another rope. About 25 maunds of wax can be exported from the district annually.

South Kánara.—The hill tribes gather honey and wax from the rocky spurs of the Western Ghâts. Coondapoor taluk furnishes 40 maunds a year, Udipi 50 maunds, Mangalore 5, Uppinangadi 7, and Kásaragod 20.

The quantity of wax exported ten years ago was—

	1891-92.	1892-93.	1893-94.
Cwts.	200	84	75
Rupees	15,922	6,802	6,116

Rupees 5 to R20 a maund are the prices between which it fluctuates in the district.

The following were the prices for bees'-wax in the Madras Presidency in 1894:—

	Per pound. a. p.
Nallamaláis, Kurnool	1 4
North Arcot	1 8
Nellore	2 2
Waltair, Northern Circle	2 4
South Coimbatore	4 6
South Kánara	3 2 to 12 8
Ganjam	6 0 to 7 0
North Malabar	8 0
Tinnevelly	9 0 to 10 0
Vizagapatam (average)	11 0
South Malabar	12 0
Cuddapah (at Madras)	9 6 to 12 8

Middle men or Chetties purchase wax from the jungle tribes of Arcot, Kurnool and Nellore and resell at twice and three times the price at large towns. The Madras maund is the usual weight by which wax is sold, this is equivalent to the weight of 1,000 tolas or rupees, or 25 pounds. The prices at South Kánara annas 3-2 to 12-8 is equal to R5 to R20 per maund.

Burma.

BURMA.—Honey and bees'-wax are collected in Upper and Lower Chindwin, Kátha, Mandalay, Pyinmána, Minbu and Tenasserim. The season for taking the combs and selling the products is from March to May. The Chins at this time of the year are particularly energetic in collecting over the large tract of country at the foot of their hills. The Chins have an interesting custom with regard to the

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gathering of the combs. In some villages each man has a recognised claim to collect over a certain locality; this claim he has inherited from his ancestors, and on his death, the privilege descends to one of his children.

Species of Bee.

The bees of Burma are of four kinds. The *Pya gyi* (**Apis dorsata**) is the largest, about an inch long, blue black on the dorsal surface with yellowish sides. The combs are found on huge forest trees and occasionally in crevices of rocks. The combs sometimes weigh from 25 to 30 viss, or on an average 15 to 20 viss; one of these will yield from 5 to 10 lbs. of honey and 1 to $1\frac{1}{2}$ lbs. of wax.

The *Pya-aung* is a medium-sized bee building chiefly in the hollows of trees.

The *Yin pya* or **Apis florea** is the smallest kind, and builds small combs in bamboos and bushes which yield only $\frac{1}{4}$ to $\frac{1}{2}$ lb. of wax each.

Collection.

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The *Pya gyi* is the most important, as the honey of the other bees is often tainted and the wax very dark in colour. In the season a party of wax-gatherers consisting of three men, one being an expert climber, proceed to the forests. The bees are stupified or driven off by means of smoking torches, and the hives are then cut off and lowered by ropes to the men below. The smoke of a Burmese cheroot is sufficient to drive off the bees from a small comb. The Karens ascend trees for the purpose of obtaining honey by means of bamboo spikes driven into the wood. When combs are found on the sides of steep cliffs and limestone rocks in the hills, the collector, suspended by a rope-swing, knocks off the whole of the combs with a pole and they fall to the bottom of the hill. Bees are much more plentiful when the **Strobilanthes** (*panthinbin*) is in flower, an event which happens about every six years.

A curious ceremony is performed in the Kabaw valley, Upper Chindwin District, by certain associated villagers when the flowering takes place. The villagers build bamboo hives near their villages, and after having made offerings to their *Nats* (wood demons, Dryads) they, after having themselves gone through a complicated ritual accompanied with songs sung in the Kudu dialect of the Shán language, invite the bees to swarm, the Sháns at the same time make as much noise as possible by striking tortoise-shells with a stick made from a fresh-water cat-fish (dried in the sun till it is like a bone, *Nga-yan*). They then leave the hives, visiting them every now and then to see if bees have swarmed, and going through the rite again on any sign of a swarm. If swarming follows, they eat the resulting honey. This festival coincides with the flowering cycle of the *Moyan*, a species of **Strobilanthes**, shrubs of which genus are known to blossom at regular intervals in hilly regions of Southern India as well as Burma.

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CENTRES OF TRADE.

Burma.

A considerable and expanding trade in bees'-wax is carried on in the Upper Chindwin Division; the duty returns for the two years, 1892-93 and 1893-94, being 1,636¼ viss and 3,541 viss, respectively. These amounts of revenue were paid at Kindat. The honey is of poor quality, and is only used by the Burmans, but the wax collected by the Chins is brought for sale to the Kabaw Valley and to several riverside villages on the upper reaches of the Chindwin up to Kanti.

The trade is in the hands of Burmans and Chinese who pay R1 to R1-8 to the Chins for the wax. The value at Kindat being R2 per viss and the Government duty 12½ per cent. *ad valorem*, so it will be seen that there is a wide margin for profit in wax transactions.

Lower Chindwin.

In Lower Chindwin Maukadaw is the centre of the honey and wax industry. The supply is abundant, and if communications were better in the Mahamyaing Forest, there is no doubt that trade could be greatly developed. The three bees peculiar to this Division are the *Pya-gyi* (**A. dorsata**), the *Yin-pya*, which makes a comb with a smaller proportion of wax, and the small dammar-bee producing the black substance called Pwe-nyet.

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Some of the largest combs of the **Apis dorsata** yield about 50 viss of wax. The annual outturn of wax is said to be between 2,000 and 3,000 viss.

Eastern Circle.

In the Eastern Circle, Upper Burma, wax is a minor forest product obtained from Bhamo, Kátha, Mandalay and Pyinmána. In 1893-94 the total amount obtained by license was 573 viss valued at R126, an improvement on the previous year which was given as 250 viss valued at R50. These figures do not give the whole of the amount extracted from the forests, as some of the licenses are purchased in kind. For instance in Kátha there were 10 licenses issued in 1892, 28 in 1893, and 22 in 1894, and reckoning 30 viss of wax for each license, a very fair estimate may be obtained of the amount extracted by each license holder.

Western Circle.

In the Western Circle honey and wax are gathered in Upper Chindwin and Minbu; in the former division, in 1893-94, 187 licenses brought in 4,437 viss valued at R935, and in the latter division 5 licenses gave 500 viss valued at R10. The total yield of the Circle for the year returned a considerable increase over that of 1892-93, which was returned at 2,036 viss valued at R460.

The right to collect bees'-wax and honey in the forests in Tenasserim is sold by public auction yearly. The following table gives the amount realized during the five years :—

1888-89.	1889-90.	1890-91.	1891-92.	1892-93.
R	R	R	R	R
1,286	895	545	1,105	1,085

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Burma.

The price of bees'-wax in Lower Chindwin, Pyinmána and Kátha is R2-8 per viss of 3·65 lbs., or 10·9 annas per lb. This is the rate in the jungle, in the towns it is 50 per cent. higher.

Tenasserim.

In Tenasserim the price fluctuates from R2 to R5 per viss (8¾ annas to R1-5-11 per lb.) as shown by the market rates in the following townships: Yé R5, Wagaru R2, Zaya R4, Ataran R2-8 to R3, East Salween R2. The markets are not supplied from local collections, but the wax is imported from Moulmein. In 1893-94, 22 cwt. of wax valued at R1,976 was exported from Mergui on the Tenasserim coast.

There are no records of any successful domestication of bees in Burma. The Kachins are said to have domesticated some forms of the wild bee, and in some of the hills experiments were made with the stingless bee (A. florea ?), but it was found to give so little honey that the trials were abandoned.

EXPORTS FROM INDIA.

The following is the quantity of bees'-wax exported from the whole of India to foreign countries during the past twenty-four years :—

	Cwt.	R
1878-79	3,311	2,66,644
1880-81	6,592	5,45,110
1885-86	5,635	4,11,127
1887-88	5,989	4,61,605
1888-89	4,573	3,45,911
1889-90	4,222	3,05,499
1890-91	6,514	4,73,630
1891-92	5,814	4,47,375
1892-93	4,667	3,68,261
1893-94	5,816	4,90,874
1894-95	7,487	7,05,247
1895-96	5,882	5,64,715
1896-97	3,142	2,76,190
1897-98	3,537	2,80,806
1898-99	4,846	3,89,379
1899-1900	5,787	4,64,172
1900-01	5,059	4,26,917
1901-02	4,139	3,64,179
1902-03	4,481	3,84,753

Exports from	
Bengal	3,020
Bombay	762
Madras	427
Burma	230
Sind	42
	4,481

To	Cwts.
Straits	2,062
United Kingdom	1,313
Germany	534
Ceylon	312
France	176
United States	67
Java, Belgium, Mauritius, etc.	17
	4,481

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USES OF WAX.

THE USES OF WAX.

Bees'-wax is known in India under the following vernacular names :—

Mόm, HIND., BENG., DEC., PERS.; *Sinth*, KASH.; *Mena*, MAR., KAN.; *Min*. GUZ.; *Moshukkin*, *méllugú*, TAM.; *Mainam*, *minum*, TEL.; *Mezhuka*, *lelin*, MALAY.; *Phayonie*, BURM.; *Madhujam*, *siktha*, SANS.; *Shama*, ARAB.; *Itti*, CINGH.

Compared with the amount exported wax has only a limited use in the country, but for many years it has regularly been employed in minor industries. Tavernier in his "Travels," Vol. II., p. 413, says: "Wax is cheap throughout India and is easily bleached, every religious house always has a large supply of wax tapers on account of the festivals when numbers are lighted before the grand altar and in all the chapels. Even the least of the Dutch sailors had 30 or 40 of the tapers for his share, and some of them had some as thick as the thigh."

A considerable amount of wax from the Western Coast is sent to Goa annually to be made into candles for burning in the churches during religious services, and in Burma thousands of wax candles illuminate the pagodas during Buddhist ceremonies.

In the Central Provinces it is used by Chipas for stamping patterns on cloth. And in Burma it makes wax-resist patterns for dyeing silk. In North Arcot it enters into the preparation of wax cloth.

The Kasarars and Lonars (metal-workers) use wax for making impressions and moulds of images and for other purposes.

Wax is one of the ingredients for preparing artificial flowers.

In medicine white and yellow wax enter largely into the manufacture of ointments and plasters. Under the name of Cera flava (yellow wax) and Cera alba (white wax) it is official in all the Pharmacopœias.

CHEMICAL EXAMINATION.

CHEMICAL EXAMINATION OF THE WAX.

Bees'-wax is chiefly a mixture of cerotic acid and myricin or myricyl palmitate. In smaller quantities there occur also melissic acid in the free state, and myricyl alcohol and ceryl alcohol. Small quantities of unsaturated fatty acid and hydrocarbons have also been found. Schwalb has isolated two hydrocarbons, heptocosane melting at 60·5 and hentriacontane melting at 67°C.

The ratio of free acid, regarded as cerotic acid, and myricin, has been found by Hubl and Hehner in a number of well-agreeing experiments as 14 : 86.

Bees'-wax is almost insoluble in cold alcohol, but boiling alcohol dissolves from it the bulk of cerotic acid and a small quantity of

CHEMICAL EXAMINATION.

myricin. An alcoholic solution is acid in reaction. On cooling a hot alcoholic solution of wax cerotic acid separates out in the form of thin needles so completely that the solution does not become turbid on mixing with water, a slight opalescence only appearing.

Warm ether dissolves bees'-wax with facility; chloroform dissolves it in the cold, leaving behind any impurities.

Bees'-wax is frequently adulterated in the European markets. The usual adulterants are water, mineral matters (yellow ochre, gypsum, etc.), flour and starch, tallow, stearic acid, Japan wax, carnauba wax, resin, paraffin wax or cerasin. The mineral and vegetable structures may be detected with the microscope or some simple methods, but the identification of foreign fats and waxes requires a more intimate acquaintance with the chemical character and constituents of the wax.

The constants of European bees'-wax as given by Lewkowitsch in "Chemical Analysis of Oils, Fats and Waxes" are arranged below :—

		Mean.
Melting point . . .	61·5°— 65°	63·2°
Acid value	16·8 — 21·2	19
Ether value	71·8 — 76·1	73·9
Saponification value . .	87·8 —107·0	97·4
Iodine value . . .	7·9 — 11	9·4

These numbers apply to the wax secreted by bees of different species, such, for instance, as that of **Apis mellifica**, *Linn.*, and **A. ligustica**, *Spinola*, showing the practical identity of samples from different zoological sources. In testing samples from different countries, provided they are genuine and unadulterated, the results accord substantially with the above figures.

Adulterants.

In order to compare the numbers or constants with those of other materials used for adulterating bees'-wax the following table is appended :—

	Melting point.	Acid value.	Ether value.	Saponification value.
Japan wax	54°	20	200	220
Carnauba wax	84°	4	75	79
Chinese wax	81°	trace	63	63
Tallow	45°	4	176	180
Stearic acid	71°	195	...	195
Rosin	100°	140	20	160
Paraffin or Cerasin . . .	44—61°	...	...	...
Pure wax	63°	20	75	95

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CHEMICAL EXAMINATION.

According to this table the lowering of the acid and saponification values of a sample would indicate the presence of paraffin wax, and a higher value than the normal would show possible adulteration with stearic acid, tallow or Japan wax. Mixtures, however, may be made of these materials which resemble bees'-wax in so many particulars that it would be difficult to detect the sophistication by ordinary methods of analysis.

Regarding the bees'-wax of Indian origin it does not appear that authentic samples have been subjected to any systematic examination, although it readily finds markets in different parts of the world and realises fair prices when carefully refined. In a paper by G. Buchner on "The Analysis of Bees'-wax" abstracted in the *Journ. Soc. Chem. Industry*, 1901, a short notice is given of a particular kind of Indian wax. Under the name of "Ghedda wax" the author states :—

Ghedda Wax.

"This is a very plastic, aromatic wax derived from British India. It gives very abnormal figures, and the author has frequently met with a sample giving results such as—Acid value 5·33, Ether value 88·35, and Saponification value 93·68."

With the object of making a fuller enquiry into the subject and to test the relative values of a series of waxes from different parts of India the samples in the Indian Museum were examined. These specimens had been sent in answer to the circular letter sent by the Reporter on Economic Products, and a large number of the waxes had been prepared from the combs of bees which were entomologically identified. In the accompanying list is set forth the registration number, locality of collection, appearance of the sample and, when possible, the origin of the wax.

List of samples.

Reg. No.	District.	Origin of wax.	Colour of wax.
280	Panjáb	......	Dirty white.
284	Madras . . .	......	Clean white.
285	" . . .	......	Whitish.
286	Poona, Bombay . .	......	Dirty white.
287	Birbhum, Bengal . .	......	White.
308	Simla, Panjab . .	......	Light yellow.
309	Jessore, Bengal . .	......	Brownish, dirty.
310	Burma	......	Dirty white.
318	Poona, Bombay . .	......	Ditto.
327	Madras . . .	......	Light brown.
328	" . . .	......	Light brown, dirty.
339	Birbhum, Bengal . .	......	Dirty white.
1459	Andaman Islands . .	......	Black.
4608	Ráipur, Central Provinces	Apis dorsata . .	Dull white.
4610	" " "	" florea . .	Brownish, dirty.

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List of samples.

Reg. No.	District.	Origin of wax.	Colour of wax.
4614	Ráipur, Central Provinces	Trigona sp. . .	Black.
4616	Nagpur, „ „	Apis florea . .	Ditto.
4624	Nimár, „ „	„ „ . .	Ditto.
4630	Cuddapah, Madras .	„ dorsata . .	Yellowish white.
4743	Godhra, Bombay . .	......	Light brown.
4744	Panch Mahàls, Bombay .	Apis florea . .	Dirty white.
4745	Jhalad Taluq, Bombay .	„ „ . .	Whitish.
4755	Sundarbans, Bengal .	Apis dorsata . .	Dirty white.
4756	„ „ .	„ „ . .	Whitish.
4760	Damoh, Central Provinces	„ indica . .	Dull white.
4761	„ „ „	*Kote* (Trigona) . .	Black.
4762	Jabalpur, Central Provinces	......	Whitish.
4765	Nilgiris, Madras . .	Apis indica . .	Light brown.
4785	S. Coimbatore, Madras .	„ dorsata (pure) .	White clean.
4803	Chaibassa, Bengal . .	„ dorsata . .	Very impure.
4832	Dhárwár, Bombay . .	„ florea . .	Dull, whitish.
4874	Sirsi, Kánara, Bombay .	Trigona sp. . .	Brownish black.
4912	Dehra Dun, United Provinces	Apis dorsata . .	Dull white.
4916	„ „ „ .	„ „ . .	Dirty white.
4963	South Malabar, Madras .	„ „ . .	Light yellow brown.
4968	North „ „ .	„ „ . .	Light brown.
5031 and 5035	Nellore, „ „ .	„ indica . .	Dull white.
5047	Sambalpur, Central Provinces	„ dorsata . .	Whitish.
5049	„ „ „ .	Trigona sp. . .	Black.
5051	Chhindwárá, Central Provinces	Apis dorsata . .	Light brown.
5053	„ „ „ .	„ florea . .	Black.
5137	Trichinopoly, Madras .	......	Dull white.
5199	Bashahr, Panjáb . .	......	Light brown.
5613	South Kánara, Madras	Apis florea . .	Brown.
5616	Coondapore, „ .	Trigona sp. . .	Black.
5617	South Kánara, „ .	Thodijiga bees .	Light brown.
5720	East Khándesh, Bombay .	Apis dorsata . .	Brownish.
5726	„ „ „ .	Trigona sp. . .	Light yellowish brown.
5746	Hazára, Panjáb . .	Apis dorsata . .	Brown.
5766	Coimbatore, Madras .	„ „ . .	White clean.
5768	„ „ .	Koorbuthan bees .	Yellow brown.
5774	„ „ .	Apis indica . .	Very light brown.
5777	„ „ .	„ dorsata . .	Dull white.
5780	Madras . . .	„ „ . .	Yellowish white.
6009	Mussoorie, United Provinces	„ sp. (Autumn) .	Dull white.

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of the Bees'-wax of British India. (*D. Hooper.*) BEES.

CHEMICAL EXAMINATION.

List of samples.

Reg. No.	District.	Origin of wax.	Colour of wax.
6138	Gurdáspur, Panjáb	Apis dorsata	Light brown dirty.
6141	,, ,,	,, indica	Brownish.
6241	Dehra Dun, United Provinces	,, dorsata	Soapy colour.
6244	,, ,, ,,	,, indica	Yellowish.
6308	Sooligarh, Central Provinces	,, dorsata	Dirty white.
6529	Rawalpindi, Panjab	,, indica	White.
6653	Almora	,, dorsata	Dirty white.
17949	Sundarbans, Bengal	Refined	Ditto.
21061	Sahávanpur, United Provinces	Apis dorsata	Yellowish.
21062	,, ,, ,,	Refined	White.

Constants determined.

In the following tables the results of the examinations are classified according to the origin of the specimens. Figures are given for the melting point, acid value, saponification value, ether value and iodine value.

Melting point.—This was taken by means of a glass capillary tube suspended in water by the side of a Centigrade thermometer. The temperature was read off immediately the melting wax rose in the tube.

Acid value.—This was determined by heating the wax in boiling alcohol and noting the amount of alcoholic potash required to neutralise the free acids, using phenol-phthalein as an indicator.

Saponification value.—The amount of caustic potash (K H O) required to saponify a weighed quantity of the wax, after boiling for three hours in an inverted condensor.

Ether value.—This figure is arrived at by subtracting the acid value from the saponification value.

Iodine value.—Hubl's method of estimation by means of an alcoholic solution of iodine and mercuric chloride was employed. The iodine solution was allowed to act for 12 hours.

The Specific Gravity was only determined in a few selected samples. While English bees'-wax had a density of 0·960, three samples of Indian wax varied between 0·953 and 0·964. The **Trigona** wax like that of the adulterated samples had a higher gravity, *viz.*, 0·980 to 1·000, and therefore scarcely floated in water.

When much dirt was present the sample was dissolved in chloroform to remove impurities, and the analysis was conducted on the clarified portion.

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ANALYSES.

Analyses of Bees'-wax.

Reg. No.	Melting point.	Acid value.	Ether value.	Saponification value.	Iodine value.	REMARKS.
	BEES'-WAX SAMPLES (ORIGIN NOT STATED).					
280 .	66°	7·4	87·8	95·2	8·2	
284 .	61·5°	10·2	87·8	98·0	6·5	
285 .	62·2°	8·8	87·2	96·0	5·1	
286 .	66°	10·8	87·8	98·6	4·9	
287 .	62·2°	11·5	83·0	94·5	4·5	
309 .	68°	11·1	80·4	91·5	7·2	
310 .	68°	13·2	74·8	88·0	2·3	
318 .	63·5°	8·3	84·7	93·0	4·0	
327 .	62°	7·2	84·3	91·5	6·6	
328 .	62·5°	7·2	80·8	88·0	4·5	
339 .	62°	8·3	93·7	102·0	5·1	
4743 .	63°	8·1	89·4	97·5	7·1	
4745 .	63°	7·3	85·2	92·5	5·9	
4762 .	61·5°	7·4	97·6	105·0	5·7	
5137 .	61·5°	7·3	92·7	100·0	5·7	
5199 .	66·5°	5·2	80·2	85·4	10·7	
5617 .	65°	9·5	136·1	145·6	5·9	
5726 .	62°	10·4	87·5	97·9	8·8	
5768 .	64°	5·8	92·8	98·0	8·5	
6009 .	69°	6·1	83·9	90·0	9·7	
Average .	63·9°	8·5	88·9	97·4	6·3	
Maximum	69°	13·2	136·1	145·6	10·7	
Minimum	61·5°	5·2	74·8	85·4	2·3	
	Apis florea.					
4610 .	63·2°	6·1	85·9	92·0	9·0	
4744 .	64°	7·7	80·8	88·5	11·4	
4832 .	68°	6·7	123·8	130·5	7·7	7·9 per cent. insoluble.
5053 .	63°	8·4	84·0	92·4	6·0	3·6 per cent. insoluble.
5613 .	63°	8·9	103·7	112·6	6·0	Impure.
Average .	64·2°	7·5	95·6	103·2	8·0	
Maximum	68°	8·9	123·8	130·5	11·4	
Minimum	63°	6·1	80·8	88·5	6·6	

Apis florea.

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CHEMICAL EXAMINATION.

ANALYSES.

Analysis of samples of Bees'-wax.

Reg. No.	Melting point.	Acid value.	Ether value.	Saponification value.	Iodine value.	REMARKS.
			Apis dorsata.			
4608 .	62°	7·2	97·8	105·0	5·2	
4630 .	62°	9·1	80·9	90·0	6·2	
4755 .	63°	10·2	87·3	97·5	4·8	
4756 .	64°	7·3	87·7	95·0	5·0	
4785 .	62·5°	4·4	90·7	95·1	5·2	
4803 .	61°					Very impure.
4912 .	67°	7·7	84·3	92·0	7·8	
4916 .	63°	6·6	91·0	97·7	8·3	
4963 .	63°	6·6	93·4	100·0	6·9	
4968 .	62·5°	7·4	97·5	104·0	6·7	
5047 .	62°	7·2	90·4	97·6	6·1	
5051 .	60°	5·9	91·7	97·6	6·9	
5720 .	66·5°	6·1	69·5	75·6	9·0	4·5 per cent. insoluble
5746 .	66·5°	8·2	91·8	100·0	9·9	
5766 .	64°	5·2	95·6	100·8	5·7	10·5 per cent. insoluble.
5777 .	61·5°	5·9	89·3	95·2	5·9	
5780 .	62·5°	7·3	90·7	98·0	5·3	
6138 .	62°	7·4	92·8	100·2	7·6	7·5 per cent. insoluble.
6241 .	64°	8·3	81·7	90·0	9·0	
6308 .	64°	6·6	94·2	100·8	5·9	
6653 .	62°	6·1	85·1	91·2	7·3	
21061 .	63°	5·8	86·6	92·4	8·0	
17946 .	61°	8·1	92·7	100·8	5·2	
Average .	63·1°	7·0	89·4	96·2	6·7	
Maximum	67°	10·2	97·8	105·0	9·9	
Minimum	60°	4·4	69·5	75·6	4·8	
			Apis indica.			
4760 .	62°	6·6	95·9	102·5	6·9	
4765 .	64°	5·8	94·2	100·0	5·3	
5031 } 5035 } .	63°	7·3	85·4	92·7	9·2	
5774 .	63°	7·3	93·0	100·3	5·7	
6141 .	63·5°	5·0	85·0	90·0	8·5	
6244 .	64°	8·8	84·0	92·8	8·9	
Average .	63·25°	6·8	89·6	96·2	7·4	
Maximum .	64°	8·8	95·9	102·5	9·2	
Minimum .	62°	5·0	84·0	90·0	5·3	

Apis dorsata.

Apis indica.

BEES. An Account of the Sources, Preparation, Trade and Composition

CHEMICAL EXAMINATION.

ANALYSES.

Analyses of Bees'-wax.

Reg. No.	Melting point.	Acid value.	Ether value.	Saponification value.	Iodine value.	REMARKS.
			Trigona sp.			
1459 .	72°	18·5	55·2	73·7	47·6	
4614 .	68°	20·9	94·9	115·8	48·3	3·1 per cent. insoluble.
4616 .	76°	21·7	128·3	150·0	30·2	
4624 .	70°	22·9	56·9	79·8	42·9	6·3 per cent. insoluble.
4761 .	69°	20·8	74·4	95·2	48·0	
4874	72°	22·8	100·2	123·0	49·6	22·6 per cent. insoluble.
5049 .	66°	22·7	123·0	145·7	48·2	4·5 per cent. insoluble.
5616 .	71·5°	16·1	84·0	100·1	39·1	
Average	70·5°	20·8	89·6	110·4	42·2	
Maximum .	76°	22·9	128·3	150·0	49·6	
Minimum .	66°	16·1	55·2	73·7	30·2	
			Adulterated Wax.			
308 .	44°	42·3	143·5	185·8	5·7	
6529 .	43°	36·6	162·9	199·5	3·8	
21062 .	44°	27·7	165·6	193·3	7·1	
			English Bees'-wax.			
	65°	20·15	77·05	97·20	9·99	

Trigona sp.

Adulterated Wax.

English Wax.

In studying these tables of analyses two very interesting facts will be revealed. The first is the lower acid value of Indian bees'-wax ; this indicates a different ratio between the cerotic acid and myricitin compared with that of waxes from other parts of the world, and the second is the uniformity in composition of the secretion of the three kinds of Indian bees representing the **Apis** family. The appearance of the wax from the three species gives no clue to the origin, and although there are two or three somewhat abnormal deviations from the average on account of the high saponification value and the wide range of the iodine value, there is very little, if any, suspicion of adulteration. The wax from the combs of **Apis dorsata, A. indica** and **A. florea** is, therefore,

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practically identical in composition, and a combination of the wax of one species with that of another cannot be regarded as a fraudulent admixture. It must be admitted, however, that the **Apis dorsata**, because of the much larger comb it manufactures, is the chief source of the bees'-wax of the country.

Trigona Wax.

The wax of the **Trigonæ** has quite a different character and composition compared with that of the true bees. The blackish colour, sticky consistence, and higher melting point, acid and iodine values readily distinguish it. These features at once separate it from ordinary bees'-wax, although, according to some of the forest collectors, the origin of wax of this nature was attributed to **A. florea.** From descriptions of the Propolis or resinous wax used in the hives of domesticated bees it would seem that the secretion of species of **Trigona** is very similar. An analysis of this material by Greshoff and Sach (*Pharm. Weekblad.* 47,933), however, showed that it consists of a mixture of 84 parts of resin, 12 parts of wax with 4 parts of an impurity insoluble in alcohol. The resin melted at 60° and the wax at 66°.

Propolis.

As before mentioned, the honey of the comb has a peculiar flavour and is valued by some tribes for its medicinal properties.

Adulteration.

Among these specimens were three purchased in the bazars of Simla, Rawalpindi and Sahâranpur which were decidedly adulterated or were foreign substitutions. They were called "refined wax" and differed in appearance from ordinary white wax in resembling white bar soap. In some respects it had a great resemblance to Japan wax. The specific gravity was high and the melting point much lower than bees'-wax, and on ascertaining the acid and saponification values it was found that the figures were double those of genuine wax. On applying Fehling's test, as recommended by Röttger, a precipitate resembling stearic acid separated from the diluted solution. Enquiries as to the origin of the refined wax from Sahâranpur resulted in tracing it to Bombay where it was probably imported from Europe.

It is satisfactory to record that out of 64 samples collected from different parts of India only 3 were really adulterated, or less than 5 per cent. of the total, and there is no evidence that the sophisticated wax was a native product or was manufactured in the country.

Conclusions.

From the above review of the existing information we may draw the following conclusions :—

1. Indian bees'-wax is derived from three species of bees : **Apis dorsata, A. indica and A. florea,** but chiefly from **A. dorsata.**
2. The wax separated from the combs of the three species of bee are substantially identical in composition, and is rarely mixed for fraudulent purposes.

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BEES. **An Account of the Bees-wax of British India.**

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Conclusions.

3. Indian bees'-wax differs analytically from that of Europe chiefly in its lower acid value.
4. Indian bees'-wax is procurable in large quantities, and the trade, which has remained almost stationary for the past twenty years, is capable of great expansion.

With regard to the last conclusion it may be said that much attention has been given of late to the subject of apiculture in the West Indies with very successful results. During the ten years from 1888 to 1898 the value of bees'-wax exported has increased from £4,823 to £10,389. Some share of this increase is no doubt due to the intelligent action of the Jamaica Agricultural Society in employing experts to make periodical visits to the country districts and to encouraging a better system of caring for the bees and recovering honey and wax. Another feature of success is the high class quality of the wax sent to the London market and the consequently good prices realized.

In India the industry is in the hands of almost wild tribes and the wax is refined by very primitive methods without any special regard to appearances. There is therefore in this country vast opportunities of improvement. The sources of supply might be visited and a study made of better methods for collecting the combs and preparing the wax for the market by more economical processes. Spasmodic attempts have been made in different districts to domesticate the bees, but no really satisfactory results can be shown. A closer acquaintance with the habits of the wild bees and the flowers they frequent is urgently required, and an earnest enterprise in this direction is almost sure to meet with success.

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G. I. C. P. O.—No. 596 R. E. P.—4-7-1904.—2,500—P. M. M.

THE

AGRICULTURAL LEDGER.

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THE AGRICULTURAL LEDGER.

1904—No. 8.

MARSDENIA TENACISSIMA.

(RÁJMAHÁL HEMP.)

[*Dictionary of Economic Products, Vol. V.*, M. 299-301.]

PAPERS RELATING TO FIBRE OF **Marsdenia tenacissima**.

i. *Report upon the Fibre by* PROFESSOR WYNDHAM R. DUNSTAN, F.R.S., *Director, Imperial Institute, London.*

ii. *A note upon the use of* **Marsdenia** *in the Rájmahál Hills, by* I. H. BURKILL, *Officiating Reporter on Economic Products to the Government of India.*

A report upon the Fibre of Marsdenia tenacissima *by* PROFESSOR WYNDHAM R. DUNSTAN.

PROFESSOR DUNSTAN'S REPORT.

A sample of the fibre of **Marsdenia tenacissima**, shown at the Colonial and Indian Exhibition of 1886, was examined by Messrs. Cross and Bevan, who reported that it was of excellent quality, and that in point of fineness and durability it ranked next to Rhea fibre (*Report on Indian Fibres*, page 33).

History of enquiry.

Since it appeared desirable to investigate more fully the properties and possible applications of this fibre, the Imperial Institute requested the Reporter on Economic Products (F. S. No. 28) to procure a sample for this purpose. Considerable difficulty was experienced in India in collecting an authentic specimen of the fibre, but a sample (Reg. No. 16080) was eventually forwarded and is described in a letter from the Officiating Reporter on Economic Products, dated the 15th May 1902, (1046—94 F. S.). It is stated that the plant is fairly abundant in the Rájmahál Hills, but that the process of extracting the fibre is both tedious and laborious, being mainly carried on by hand-stripping.

MARSDENIA tenacissima. Papers relating to Fibre of

PROFESSOR DUNSTAN'S REPORT.

The sample consisted of a very strong, fairly white fibre with a staple of an average length of 12-13 inches. The results of its chemical examination in the Scientific and Technical Department of the Imperial Institute are given below, and those of Messrs. Cross and Bevan, obtained from the former sample.

Analyses compared.

	Sample 16080.	Cross and Bevan.
	Per cent.	Per cent.
Moisture	7·7	4·5
Ash	1·5	1·5
a—Hydrolysis loss	7·8	6·2
b— Ditto "	8·9	10·1
Mercerising "	4·9	4·6
Acid purification "	3·5	0·8
Nitration gain	53·9	31·0
Cellulose	91·5	88·3
Length of ultimate fibre	10—30 mm.	5—20 mm.

The fibre contains little or no lignocellulose; this is shown especially by the absence of colour in the nitration product and by the fact that when the chlorinated product, obtained in the course of the estimation of cellulose, is treated with sodium sulphite no red coloration is produced. It is exceptionally resistant to the action of alkali as is indicated by the comparatively small losses sustained on hydrolysis and mercerising. The remarkable quality of this fibre is shown also by the unusually high percentage of cellulose and by the large increase of weight on nitration.

The present specimen is seen to be of better quality than that examined by Messrs. Cross and Bevan; it is richer in cellulose and shows a much larger increase of weight on nitration, whilst the average length of the ultimate fibre is also somewhat greater.

Valuation in London market.

Representative specimens of this fibre have been submitted to two leading firms of fibre brokers for commercial valuation. One firm reports that the fibre, although short, is of great strength and therefore likely to be of value. It is suggested that sample bales should be sent for trial. The other firm reports that the fibre is very strong but harsh. It is too short for machine spinning and consequently could only be utilised as tow. The sample is said to be worth from £15 to £18 per ton (of a length of 12-15 inches); if, however, the fibre could be sent of a length of 30-50 inches, its value would probably be from £35 to £40 per ton.

From the foregoing report, it is seen that the fibre is one which might be of importance, whilst the chemical examination shows that it possesses properties which are considerably above the average of those of ordinary fibres. The question arises, therefore, whether

experiments in cultivating the plant should be undertaken as it is understood to be of comparatively rare occurrence in India, and also whether the fibre could be successfully treated by machinery.

POSSIBILITY OF USE IN EUROPE.

A note upon the use of Marsdenia *in the Rájmahál hills by* I. H. Burkill.

MARSDENIA IN THE RÁJMAHÁL HILLS. Introductory.

Sir Frederick Abel, the late Director of the Imperial Institute, having been interested by the article on **Marsdenia** in the Dictionary of Economic Product, in 1894, asked that samples of the fibre might be collected for chemical examination. The fibre was collected, and the result of that proposed examination is now before the reader in the report by Professor Dunstan, printed above. The fibre was collected in the Rájmahál hills, Bengal, by the late Deputy Conservator of Forests, Santál Parganas, H. D. D. French, Esq., who spared himself no pains in the search for the right stuff. It is melancholy to think that I had written to him, requesting that he would write this note, on the very day of his death. Nothing new has been published regarding **Marsdenia tenacissima** since 1891, when the article on it in the *Dictionary of Economic Products* appeared: and much of the information which I have briefly to give here, was collected by Mr. French.

VERNACULAR NAME.

When Sir Frederick Abel opened the enquiry we did not possess the vernacular name by which the Santáls of the Rájmahál hills know it. Royle had called it the *Jiti* fibre. Enquiry was therefore made for *Jiti*, and for *Chiti*—a name used about Palamau and referred to **Marsdenia tenacissima,** but Mr. French did not find the names to be known. He, however, discovered that another fibre plant, *viz.*, **Spatholobus Roxburghii** passes under the not altogether dissimilar name of *Chunti* in the Paharia Sooria dialect. This plant is in Santáli the *Chihut*, and its fibre, when extracted, is called by the Paharias *Orre.*

Distinctive names of Spatholobus Roxburghii.

When the vernacular name had failed Mr. French sought for the plant wanted by its descriptions, and he was successful so that in May 1900, he reported that the Santáli name of the **Marsdenia** is *Konat* and the Mal Paharia name is *Kona* (this "n" being sounded like n in the French word "bon"). He added that "The Santáls use it as follows—for fish-lines, for fixing feathers and arrow heads to their arrows, sometimes for bow-strings, and for ornamental arm-tassels dyed black with the fruit of **Terminalia Chebula.** The Paharias use it for stringing their bead neck-laces, for fishing-lines, bow-strings, etc. In this locality (within twenty miles of Dumka), it is not as far as I am able to ascertain, brought to the bazaars for sale."

FIBRE NOW EMPLOYED BY SANTÁLS AND PAHARIAS OF THE RÁJMAHÁL HILLS.

About the beginning of May the plant comes into new leaf, it flowers in September-October. After the rains is the time when the

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MARSDENIA tenacissima.

Papers relating to Fibre of Marsdenia tenacissima.

USES.

PREPARATION OF FIBRE.

fibre is prepared. The method of preparing the fibre has been described in the Dictionary of Economic Products. To this description I find a little to add in regard to the practice of cutting the stems into short sections before peeling it and scraping the bark with the thumb nail. What I have to say explains the methods of the Santális as reasonable.

Stem cut into short lengths.

If an attempt be made to strip by hand from the stem a ribband containing the fibre, the ribband will be found to break at each node. The length of the fibre thus becomes limited by the length of the internodes and they run ordinary to about 15-20 inches in length. The breakage is due to two causes:—primarily to the greater depth in the cortex at which the fibres lie as they pass the node and to some formation of cork above them under the scars of the leaves when they have fallen, and of the stipules also, and secondarily to the ramification at the nodes of the fibres themselves.

Reason for so doing.

The fibres are little round strands of some 50-80 bast cells whose lumen is nearly filled up. They are not added to in the growth of the plant so that they are no larger in a 3-year old stem than in a 1-year old stem. Throughout the internodes the strands are perfectly parallel, but at the node two or three may draw together unite and divide up again.

As the fibres are not added to in growth, those from a first year shoot are, we may believe, as good as those from a third year shoot.

It is possible to get out the fibres without breaking them at the node by cutting or by scraping the firmer cortex from above them at the nodes, as I have proved by experiment on stems kindly obtained for me by Mr. J. S. Baker, Officiating Deputy Conservator of Forests, Sontál Parganas, but a weak spot remains. The practice of the Santáls therefore seems reasonable.

COST OF FIBRE REPORTED TO BE EXCESSIVE.

The cost of preparing the fibres was found by Mr. French to be excessive.

In June, 1902, Mr. French sent to me fishing-lines, bow-strings and amulets made of this fibre. They may be seen in the Economic Gallery of the Indian Museum. He also sent at the same time the fibre reported on by Professor Dunstan.

Most of the fibre sent was made from lengths of stem about 10 inches long, but bow-strings are made of lengths of the stem nearly three feet long picked out in the forest with great care.

USES. Thread utilised for bead chains.

The bead chains are made on thread which is very thin, corresponding to No. 40 (Kerr & Co. N. M. T. extra six cord) of the cotton thread scale of European manufactures. And an amulet is made of twisted thread of the same thickness. The fishing-line is well made, but coarse for the purpose.

M. 299-301.

G. I. C. P. O.—No. 507 R. E. P.—1-7-1904—2,500—C. M. W.

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AGRICULTURAL LEDGER.

1904—No. 9.

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THE AGRICULTURAL LEDGER.

1904—No. 9.

ALTINGIA EXCELSA.

(BURMESE STORAX.)

[*Dictionary of Economic Products, Vol. I. A.*, 892-96.]

Other DICTIONARY articles that may be consulted :

Liquidambar orientalis, Vol. V., L. 455-58.

THE PROPERTIES OF *Nan-ta-yok* OR BURMESE STORAX.

By DAVID HOOPER, F.C.S.

INTRODUCTION.

The fragrant balsam, known as Nan-ta-yōk and used in Burma in ancient times as an incense and for medicinal purposes, has recently been enquired into by the Reporter on Economic Products, and specimens deposited in the Indian Museum. When this material became available, the Reporter put the information of his gathering into my hands for the purpose of a report. The tree yielding the balsam grows in Burma and Assam, and it seems desirable to extract the secretion and endeavour to introduce it into commerce as a substitute for the valuable storax of Asia Minor which is regularly imported into Bombay, and employed, principally as a perfume, in India, Malaya and China. It grows also in Java and yields there the balsam as in Burma, and its composition and properties have been recently investigated. The information to hand is here brought into one view with that to be found in the article by Sir George Watt in his *Dictionary of the Economic Products of India.*

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ALTINGIA excelsa.

The Properties of Nan-ta-yok

BURMESE STORAX.

Altingia excelsa, *Noronha*; *Fl. Br. Ind., II.*, *429*; *Ind. Kew., I.*, *96*; HAMAMELIDACEÆ.

Syn.—LIQUIDAMBAR ALTINGIA, *Blume*; SEDGWICKIA CERASIFOLIA, *Griff.*

Vern.—*Jutili*, ASSAM; *Nan-ta-yōk, nan-ta-yu*, BURM.; *Rasa mála*, MALAY.

The tree was named by C. Noronha, a Spanish botanist and traveller, in honour of A. W. Alting, Governor of the Dutch Indies.

Habitat.

Habitat.—A magnificent tree of the tropical evergreen forests of the Indian Archipelago, Burma, Assam and Bhután; abundant in the Tenasserim province of Burma. In South Tenasserim it is scattered over the division in fairly large quantities, especially in the Kaleinoung and Heinze reserves on the Kaullaing and Nanpayok *choungs* (or streams) as well as in the Palaw and Tenasserim townships. The Nanpayok is a considerable stream in the province of Mergui which Dr. Mason states derives its name from this tree in consequence of its growing so thickly on its banks. Kurz states that it occurs also in the Kaehin (Khakyen) Hills.

Burma.

It, known as *Jutili*, is one of the principal timber trees in Upper Assam, and is taller than the **Mesua ferrea** with which it is often associated. It is very abundant on the plains near Muttock and occurs on the Mishmi Hills. Griffith who named the tree **Sedgwickia cerasifolia** (*in Asiatic Researches*, Vol. XIX, 1836, 99) found it growing between Debrumukh and Rangagurrah. He describes it as "A lofty and aromatic tree", and says that its light greyish bark holds or exudes sparingly a gum-resin with an odour of pepper.* The exudation has not been collected, in Assam, and it has not been observed by recent explorers.

Assam.

Distribution.

The tree is one of the most important timber trees of Java, growing in the western part of the Island. According to Miquel it is found in the mountainous regions of the Sunda Archipelago, New Guinea, Cochin China, and in Yunnan in China.

It is a leaf-shedding tree and reaches 150 to 180 feet in height, with a clean stem of 80 to 100 feet, and a girth of 15 to 20 feet. The wood is very hard, close-grained, with a somewhat balsamic odour. It is said that from the fruits and from the knots of the stem, a softish resin collects which burns freely and emits a strong odour of Gum Benjamin or Benzoin.

Balsamic Resin.

Balsamic Resin.— This tree is of interest because of its being the source of a resin similar to Storax or Styrax of European Commerce. Storax is obtained from a tree of the same Natural Order named

* "Gummi-resinam piperaceo-aromaticam parcam continente vel effœta."

or Burmese Storax. (*D. Hooper.*)

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BALSAMIC RESIN.

Liquidambar orientalis, *Miller*, growing in Asia Minor. Storax is imported into Bombay from the Red Sea ports and is used in medicine by Muhammadans and Hindus; it is also said to have been carried into China by Arab traders since the Ming Dynasty, A. D. 1368-1628. Three kinds of resin are described in Arabic and Persian works, *viz.*,—1st, that which exudes naturally; 2nd, that which is obtained by pressing the bark; and 3rd, that which is obtained by boiling it. The bark of the tree is fragrant and is supposed to be the drug which was formerly known by the name of **Cortex Thymiamatis**.

American Storax.

Another styrax-yielding tree is the **Liquidambar styraciflua,** *Linn.*, the Sweet Gum tree of North America. The balsam obtained from this species has a similar composition to that of the official storax, and has been gathered to a considerable extent in the United States for the preparation of chewing gum.

Rasamala of Java.

The resin of **Altingia excelsa** is the *Rasamala* of the Javanese and Malays, and this name is supposed by some to be the origin of *Rosa Mallas* and *Rosa Malœs,* the names for Storax occurring in the statistics of the early European traders. Dr. Dymock, however, considered this supposition to be incorrect as the only Rosa Malœs known in Bombay is that imported from Europe, and the Burmese Storax seems to be quite unknown in India. Moreover, the name would appear to be of European origin and has been applied to Liquid Storax incorrectly through the confusion of that substance with Honey dew or Manna collected from trees, the *Drosomeli* of the Greeks and the *Ros melleus* of the middle ages. We have on the one hand the evidence that Rosa Mallas was an alias of Liquid Styrax of the Levant in 1708 when Mr. Petiver read a note on the subject before the Royal Society of London, and on the other hand Rasamala has for over three centuries been used in the Straits. Whether these are corruptions of the same term applied to a different substance, are points not yet decided. The author of the Makhzan says:—Rasimilius is a Greek name for a kind of incense called in Arabic *Dukhân-el-dam,* and in Hindi *Ast loban* or Western Frankincense. Storax is imported into Bombay to the extent of three or four cwt. every year and is valued at about Rs. 44 per cwt. The usual trade name is *Silaras.* Its chief uses are as an incense and as a stimulant expectorant like the Balsam of Peru, Tolu and Benzoin.

Drosomeli.

urmese Storax.

Burmese Storax is at present little known and our knowledge of its preparation and uses is very scanty. Tradition says that in former times when the Burmese court resided at Pagan or Ava, and before English perfumes were introduced into the Burmese markets, a regular trade was carried on in "Nanpayok Oil," and it was used both medicinally and as a perfume. Dr. Mason

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BALSAMIC RESIN.

the author of "Burma and its People," searched the reports of **Dr. Helfer** for information about the tree, but without success. It was brought to notice by a Catholic priest, a resident of Rangoon, who introduced it in a Burmese medical treatise that was lithographed by **Colonel Burney**. This gentleman, however, seems to have confused the tree with the one that produces Balsam of Peru (**Myroxylon Pereiræ**, *Klotzsch*) which belongs to quite a different Natural Order.

Previou notices.

Dr. E. J. Waring, in *Pharmacopœia of India*, page 88, refers to two varieties of the resin met with in Burma, one pellucid, fragrant and of a light yellowish colour, obtained by simple incision of the bark; the other, thick, dark, opaque, of a highly terebinthinate odour, obtained by boring holes in the stem and the application of fire around the trunk of the tree. Samples of these two varieties were sent to the Madras Drug Committee in 1851. In an analysis of the resin by **Marquart**, quoted by **Dr. Jonathan Pareira**, it was found to contain a volatile oil somewhat like styrol, and a substance similar to styracin. The Editor of the *Pharmacopœia of India* instituted some trials with it as an expectorant, but with no satisfactory results; he came to the concusion that it was of little value as a medicinal agent.

Recent collections.

To bring the enquiry from 1868 to more modern times, the Reporter on Economic Products in 1899 received from **Mr. F. B. Manson**, Officiating Conservator of Forests, Tenasserim, three small samples of products of **Altingia excelsa**. These consisted of a fragrant oil, a crystalline fatty substance, and a black resin having a strong odour of cinnamon. Further samples were asked for, and some larger quantities of the yellow crystalline fat and the black storax-like resin were forwarded in 1901. With the latter consignment the Forest Officer sent the following particulars respecting the mode of collection. Balsamic gum or oil only oozes out of certain Nantayôk trees, and from injuries caused by insects, or where branches have fallen off and decay has set in. In the dry weather four trees were tapped in the same manner as the *Kanyin* (**Dipterocarpus turbinatus**) when the oleo-resin or wood-oil is required, but only one of the trees responded in giving the fragrant oil. A white resinous substance exuded from the fresh wounds in Palaw, but near old wounds a black resinous substance remained adhering to the bark which could only be removed with portions of this attached. The white, honey-like exudation apparently becomes converted on exposure to a dark coloured resin. The quantity found to exude from the trees was so very small that it was considered hardly worth while to collect it, unless a price commensurate with the labour were asked for the resin. After making a further trial two years afterwards, the Conservator of the district reported that the products were difficult to obtain,

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BALSAMIC RESIN.

the inhabitants in the jungles very few, and that all the trees do not respond to the attempts made to extract the storax.

In Java the tree known as Rasamala (**Altingia excelsa**) yields by incisions in the trunk an odourous resin, but the exudation issues very slowly and in small quantity. In tracing the references to Rasamala in Dutch works it is clear that in Java and the Malayan islands the name *rasamala* is given to different products. Taking the notices in chronological order it is interesting to review the opinions expressed on the nature of the fragrant substances met with under this name.

Java and Malaya.

Rumphius (*Herbarium Amboiense*, II, 57) describes under the name of "*Caju Rasamala*" or "*Lignum Papuanum*", the wood of a tree. He says the tree has been referred to the same as that which produces gum elemi, but proceeds "no gum or resin exudes, neither in the wood of the tree is any peculiar odour observed." He also remarks that it is brought from that part of new Guinea where Massoy bark is sold.

Rumphius.

Subsequently Blume referred to Lignum Papuanum as a synonym of the wood of **Liquidambar Altingiana**, and Hasskarl identified Rasmala or Rosmala with the same tree.

Blume.

Noronha (1827) in describing the plant admits that it is Rasamala in the Malay language, "which in herbals is known by the name of styrax." He observed that an oil exuded from the stem, first having the consistence and colour of honey, but afterwards turning white in the fissures of the bark and then appearing translucent and crystalline and forming into drops which do not adhere to the bark. Noronha alludes to the stryax odour being greater in the roots, and to the stem of the tree being covered with ferns and epiphytic plants; these two observations are not confirmed by subsequent writers.

Noronha.

Junghuhn (1850) described rasamala as an exceedingly pleasant smelling resin which runs like honey out of the bark, soon becoming hard on exposure to the air, and filling up cavities in the bark. These masses are to be found in the upper part of the stem and have to be obtained by felling the tree.

Junghuhn.

Wiggers writing in 1865 asserted that he had not succeeded in obtaining any balsam from the huge stems of the tree, and declared it was a mistake to say that oriental storax was obtainable from it.

Wiggers.

Dr. De Vrij, who resided in Java from 1857 to 1863, collected a hard resin in flat angular pieces, of a light yellow or amber colour, and transparent. The resin was brittle, with a shining glassy fracture, tasteless and odourless.

De Vrij.

In Javanese medicine very heterogeneous substances are employed as rasamala. When of sufficient fragrance it is used as benzoin for incense, but it is not regularly collected and placed on the market.

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BALSAMIC RESIN.

Professor A. Tschirch and Dr. L. van Itallie, in 1901, examined three samples from Java; two of them were identical, consisting of loosely adherent pieces, faintly dusty, of a light yellow colour and glassy fracture, crumbling to powder when chewed. These are designated as "*rasamala bodas*" (= white), and are derived from an Altingia tree with white wood. The third sample consisted of a conglomeration of brown resinous pieces, and was designated *rasamala beurum* (= red), derived from a tree having red wood; but both trees, according to Greshoff, were identical with Altingia excelsa. The tree is abundant and very accessible in certain parts of Java, and it might be worth while to make experiments to obtain the exudation in a manner similar to that practised in the collection of storax.

Liquid Benzoin.

A substance of the nature of the liquid balsam of Altingia is described by Hanbury in his Notes on Chinese Materia Medica, under the name of *Shuy-gan-scih-heang*, literally "Liquid Benzoin." He says "the drug is a dark brown, semi-fluid resin, having an extremely fragrant odour of storax. It is met with in small globular wooden shells, apparently the pericarp of some fruit, about 1¾ inch in diameter, closed with wax. Its origin is very obscure. The Chinese assert that they import it from the Straits, or, in other words, by way of the Indian Archipelago; but I have not been able to trace it either there or in Siam. It is curious, moreover, that this fragrant resin even to the shell inclosing it, is extremely like that kind of balsam of Peru which was brought to Europe long ago in the capsules of a Lecythis, and naturally supposed to be a product of South America. The Liquid Benzoin is very expensive, a single shell, holding perhaps half an ounce, being worth four dollars, or 20*s*."

Chemica composition.

Chemical composition.—Oriental storax is a mixture of free cinnamic acid, vanillin, styrol, styracin, cinnamic acid—ethyl ester, cinnamic acid—phenolpropyl ester, and storesinol, partly in the free state and partly as cinnamic acid ester. Storesinol has the composition $C_{16} H_{26} O_2$, and melts at 156°—157°; it is isomeric with the benzoresinol, isolated from benzoin, which melts at 272°C.

The composition of American Storax deviates so insignificantly from Oriental Storax that they may regard as identical.

MM. A. Tschirch and L. van Itallie who investigated these balsamic substances in 1901 (*Arch. d. Pharm.* (Sept. 17, 1901) 239 No. 7·506), discovered that notwithstanding the close botanical relationship between storax and rasamala resin they are widely different in composition. It was acknowledged, however, that possibly this difference is due to the various modes of collection. The authors used a light yellow variety for their examination. The two samples melted respectively at 65° and 80°C., this difference being probably due to the variable quantity of volatile oil contained

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CHEMICAL COMPOSITION.

in them. The odour is very aromatic, reminding of cinnamon, pepper and turpentine. The solubilities are as follows: partially in alcohol, methyl-alcohol, carbon disulphide and glacial acetic acid; almost completely in ether, acetic ether, chloroform and benzol; nearly insoluble in acetone and soda solution. The only constituents that have been determined with certainty are: cinnamic acid, benzaldehyde and cinnamic aldehyde. The alcoholic solution contained tannic acid, probably derived from the bark of the tree.

The two aromatic exudations from South Tenasserim will be described separately.

Soft white Balsam.

The soft white crystalline balsam.—In a fresh state this secretion resembled honey in colour and consistence, but after two years it became white and crystalline, and possessed a delightful fragrance of styrol. It melted on the surface of mercury to a clear liquid at 41°C. Heated on a water-bath until it lost weight the volatile constituents, chiefly essential oil, amounted to 7·65 per cent. The following constants were determined: acid value, 24·96; ester value, 174·39; saponification value, 199·35; iodine value, 57·3. Upon examining the soluble extract resulting from the acid determination, no free cinnamic acid was detected, but the alkali had combined with 8·3 of a light yellow resin.

The process of saponification revealed the interesting fact that about half the balsam consisted of an ester compound of cinnamic acid. The product of the action of alcoholic potash was evaporated to dryness, dissolved in water, and agitated with ether. The ether removed a yellowish fluid body neutral in reaction. On decomposing the salt with sulphuric acid and again agitating with ether a compound was removed which afforded 37 per cent. of cinnamic acid calculated on the original balsam. The tendency of the action of potash on cinnamic acid is to convert it into benzoic acid, but the product of saponification was shown to be the former acid from its melting point, degree of acidity and the peculiar reaction when treated with nitric acid.

Dark brown Balsam.

The dark brown solid balsam.—This was in fragrant, resinous masses, varying from dark brown to black, externally hard, yielding a brown powder, some portions were soft and sticky within, odour strong and pleasant, that of cinnamon predominating. The resins were mixed with portions of bark, wood and sand. Two samples clarified by means of alcohol gave:—

	1	2
Pure resins	53·72	54·70
Organic impurities . . .	19·09	28·05
Inorganic impurities . . .	22·24	10·67
Volatile oil and loss . . .	4·95	6·58
	100·00	100·00

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CHEMICAL COMPOSITION.

The purified resin had a clear amber colour and the fragrant odour of the crude Nantayôk balsam and melted at 68°C. It was soluble in chloroform, carbon disulphide and benzol, partly in acetic ether, and only slightly in petroleum ether.

The following constants were obtained on the second sample of resin which had been obtained from the Zinba forest, Tenasserim :—

	Crude resins.	Pure resins.
Acid value	52·48	76·80
Ether value	77·62	53·64
Saponification value . . .	130·10	130·44
Iodine value	41·07	51·68

On comparing the values determined by alcoholic potash there is seen to be a great difference between the soft white crystalline balsam and the dark brown solid variety. The latter contained a trace of free cinnamic acid, and only 9·7 per cent. of the acid in combination as an ester.

Cinnamic acid.

These experiments show that the soft white crystalline substance derived from the Nantayôk tree and exuding from the bark with a honey-like consistence is a valuable perfume and a rich natural source of cinnamic acid. The brown resin has the peculiar fragrance of storax and is not without value as a perfume and incense. Compared with genuine storax from the Bombay Medical Stores, the Burmese products possess a sweeter aroma. Both balsams evolve the odour of benzaldehyde when heated with potassium bichromate and sulphuric acid.

The point of some importance is to determine how these samples of Nantayôk resin or balsam differ from true oriental storax. Dr. K. Dieterich proposed in 1898 (*Pharmaceut. Centralblatt.*) a scheme for the examination of crude and refined storax. Calculating on the dried drug, he ruled that not more than 2·5 per cent. should be insoluble in alcohol, and found that samples of authentic origin possessed acid numbers of 87·62 to 95·81, ester numbers of 49·84 to 109·83, and saponification numbers of 145·82 to 199·14. According to this scheme of analysis the brown resinous balsam would be excluded from the category of true oriental storax, and the soft crystalline balsam only resembles it in regard to the saponification value.

I am thus able to confirm the results of Tschirch & van Itallie in showing that Nantayôk resin, like rasamala resin of Java, has a different constitution to true storax of Asia Minor. At the same time the products of **Altingia excelsa** are rich in aromatic compounds which recommend them for more than local use, and their collection by Forest Officers might profitably be extended in Burma and Assam.

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G. I. C. P. O.—No. 989 R. E. P.—4-8-1904.—2,500—C. M. W.

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THE AGRICULTURAL LEDGER.

1904—No. 10.

MANIHOT UTILISSIMA.

(CASSAVA, TAPIOCA, MANIOC.)

[*Dictionary of Economic Products, Vol. V.*, M. 216-30.]

Other PAPERS that may be consulted :

The Agricultural Ledger, 1897, No. 4 ; 1900, No. 15.

THE TAPIOCA PLANT: ITS HISTORY, CULTIVATION AND USES. A REVIEW OF EXISTING INFORMATION.

By I. H. BURKILL, *Officiating Reporter on Economic Products to the Government of India.*

INTRODUCTORY.

Manihot utilissima is an American plant which has been cultivated for such ages that the wild parent is no longer recognisable. Under the selection of man it has been broken up into many races, some of which have roots poisonous when raw, while others have had the poison largely eliminated from the fleshy edible inner part of the root. The plants with little or no poison in the flesh of the raw roots have a distinctive name in Brazil, *viz., Aipi*, and are our sweet cassava; while *mandiocca* or *maniba* is the esculent root of both sweet and bitter cassava. Besides differing in the way in which they contain poison, the races differ in precocity, and in yield and in the way in which they resist the evil effects of water standing on the land or waterlogging, and in their demands in temperature.

Cultivated races.

Sagot, in the *Bulletin de la Société de Botanique de France* XVIII, 1871, p. 347, says that when he travelled in Surinam there were 10-12 races cultivated in that little French Colony ; Tracy, in the *United States Department of Agriculture, Farmers' Bulletin*, No. 167, 1903, p. 7, asserts that Brazil contains 40-50 races ; there are several in the West Indies and four (*teste* Tracy) in the Southern United States. Robert Thomson (see *Agricultural Ledger*, 1900, No. 15, p. 163) says that there are many varieties in Colombia, some of which grow where the rainfall is only 14-16 inches per annum, and some where it exceeds 200 : and some of which grow in the sub-tropical belt of the mountains, and others in the hot valleys. Réunion and Mauritius, islands which received **Manihot** first a century and a half ago, have now in them several races, and Madagascar has four.

THE BRINGING OF MANIHOT TO INDIA.

Very early the Portuguese, who colonised Brazil and carried on a big slave traffic between Africa and America, brought **Manihot** to the Old World where they established it with ground-nuts and other American

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MANIHOT utilissima.

The Tapioca Plant: its History,

HABITAT.

produce. We have reason to believe, though there exists no absolute proof for the view, that they also brought the **Manihot** to their Indian possessions and established it at Goa, whence its cultivation spread.

A.D. 1786. A.D. 1794. A.D. 1820.

A fresh introduction of the plant into the East Indies occurred in 1786 when Ceylon received it through Mauritius. It was brought to Calcutta and Serampur from South America in 1794. Bennett in his *Ceylon and its Capabilities* claims that about 1820 he brought the plant into Ceylon. That would seem to be a second introduction, or possibly as the Portuguese may have grown it there even a third introduction to the island. A third introduction to the mainland of India occurred in about 1840 when it was again brought to Calcutta—this time direct from the West Indies. Burma probably received the plant from the Straits Settlements in part, in part from Calcutta or Madras *viâ* Arakan.

A.D. 1840.

How far the divergences which may now be found between races in India, are due to the introduction of different races on these occasions and how far to selection in India it is impossible to say: and it would be unwise to assume that any of the races now to be found in India have exactly the same agricultural value, the same food value or the same industrial value as races which have been the subject of experiment in other parts of the world.

Where grown in India.

Manihot is grown in Assam and Bengal in gardens, in parts of Nepal, in the United Provinces "luxuriantly" (*teste* Atkinson in *Economic Products of the North-Western Provinces*, Part V, Allahabad, 1883, pp. 22 and 23) but to my knowledge quite rarely (*vide* letter from the Superintendent of the Royal Botanic Gardens, Shibpur, in the *Agricultural Ledger* No. 4 of 1897, p. 10). It is grown all down the East Coast to Cape Comorin and up the West Coast at least as far as Goa in gardens, and in Travancore and at Pondicherry and Cuddalore, at least, in fields. In Burma it is grown here and there throughout the Province, but chiefly in the south. Chinamen are the chief cultivators of it at Tavoy. The roots are eaten cooked. I have seen it in the Northern Shán States and on the Siamese Frontier. It is only to be found in gardens and never in fields. In the Federated Malay States it is a field crop.

Assam. Aracan.

Assam and Bengal as well as the Arakan coast used to grow **Manihot** before about 1840 when the Calcutta gardens distributed the fresh strain from the West Indies. The new strain was found in Assam, as regards appearance, to be almost identical with the old strain and to be "not distinguished by the natives" (*Major Jenkins in Journ. Agri.-Horticultural Soc. India*, N. S., VII., 1850, p. 238). There do not seem to be any two recognised kinds in Assam at the present date, but only a single strain of the sweet cassava plant.

Bengal.

The same strain is the Bengal plant. However, that the bitter has been tried is indicated by Mr. A. C. Hartless in "*Indian Gardening,*" August 4, 1898. The cassava root is sold cooked in October and

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RACES. Sikkim.

November in the bazars of Sikkim. The Bengal stock, after the last famine, was sent to many remote parts of India by the **Agri.-Horticultural Society** (*vide Report, Dept. Land Records and Agriculture, Bengal*, for 1898-99, p. 34). Whether it was established in Cutch, Meywar and Sind by these efforts, is not known.

Madras.

The race of our plant to be found at Rajamandry, Madras, Pondicherry, Cuddalore, etc., is one only as far as I can judge; but a comparative study in the field is necessary to determine the point. **Sir George Watt** and **M. Poulain**, President of the Chamber of Commerce, Pondicherry, both call it sweet cassava; but they—the former in a note in my office, the latter in the *Journal d'Agriculture Tropicale*, II, 1902, p. 14,—say that at Cuddalore and Pondicherry it is always sold cooked. It is sold in Madras fresh, and I have obtained it from the bazars with the sandy soil in which it had been grown adhering to it. "From Pondicherry and Cuddalore," says **Sir George Watt**, "the cultivation of **Manihot** extends through Tanjore practically to Tinnevelly and Travancore. **Dr. Shortt**, author of a *Manual of Indian Agriculture*, and others, formerly grew a kind of the bitter cassava plant in the Shevaroy Hills. **Mr. J. Cameron**, of Bangalore, tells me that there are two races in Mysore, distinguished by the colour of their stems—the one reddish, the other green. When we reach Travancore we find no longer one or two but instead many races, to tabulate which from **Mr. A. M. Sawyer's** statement in the *Indian Forester*, XXI, 1895, p. 290, is all I can do, until a further study of them has been made.

Mysore.

Travancore.

	Height of plant.	Average weight of root.	Age at maturity.
Class I.—**Avians** or easily boilable kinds—	Feet.	lbs.	Months.
1. Pacha avian	12	15	12
2. Chini or Vellari avian	...	10	6
3. Chovalay avian	..	10	12
4. Curry avian	4	12	12
5. Chana avian	8	8	...
6. Chenkomban	(like No. 2).		
7. Neduvenganden	...	4	...
Class II.—Maravans or dark races—			
8. Olley Karim Maravan	...	10	12
9. Nedunali-kian Karim Maravan	...	...	...
10. Ana Maravan	20	20—25	15
11. Kathelay Marachini	...	...	...
12. Kcota Maravan	2-2½	...	...
13. Ellavum Kappa	(like No. 10).		
14. Ananakkum Kappa	4	small	...
15. Vellay Marachini	25	...	...
16. Olaven	3	small	...
17. Kili Vakay	10	12	...

Their cultivation according to the *Madras Manual of Administration*, 1885, II., p. 135, extended very rapidly in Travancore just before 1885.

The roots are there often cut into slices boiled and dried in the sun, and kept for future use.

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RACES.

Mr. Mollison, in a note communicated to me, states that when tried together at Cawnpore a selected Travancore race proved itself superior to the Tanjore race.

Ceylon.

Exactly how many races Ceylon has is not known, three or four are cultivated in the Botanic Gardens of that Island (*vide* Macmillan in *Indian Gardening and Planting*, 20th December, 1900).

FURTHER INTRODUCTION OF NEW RACES

Recently again the Government of India has imported new races which are under experimental cultivation at Poona. These are **Manihots** originally from Colombia but had been grown for some years in Jamaica before India received them. The sender is Mr. R. Thomson,—to whose interest and energy their acclimatisation in the West Indies is due. The names of the races which have so far been successfully grown at Poona I cannot ascertain.

Having established a stock, these plants will be tried in various parts of India.

VERNACULAR NAMES.

When introduced into India **Manihot** got new names, none of which retain any indication of foreign origin unless it be "*Manupendalum*" and most of which are easily translateable. They are as follows:—

In Sikkim the Lepchas call it *Tunglu-bok* [*i.e.*, yam with Simul (*Bombax*) leaves], the Nepalese *Simul-torul* (the name has the same meaning), the Bhutias *Sha-Shingken.*

In Assam and Bengal—*Simul-álu*, *Simla álu*, and *Hemálu állu* (*i.e.*, the yam with Simul leaves), and also *Roti-álu* (bread yam) or *Gach álu* (tree potato) or *Kath alu.* The Gáros call it *Thabalchi.*

In the United Provinces at Pertabgarh it is called *Maida-darakht* (meaning Flour tree), at Lucknow a few know it as *Alugach* (potato tree), *Shafat alu* (white yam) and *Chikna aru* (sticky yam); at Cawnpore it has been called *Simul alu* as in Bengal.

In Burma it is *Tan-u* and *Pulu-penang myouk* (Penang island yam) and *Themban myouk* (ship-yam) *Kalaw-pinan myouk*, a name received from Pegu, is a corrupt form of *Pulu Penang* or *Pilawpinan-myouk.*

On the East Coast it is *Kara pendalum, i.e.*, stick yam—sometimes the distinctive *Kara* may be dropped and the roots may be sold as *pendalum* which means "yam," or *Manupendalum.*

In the South part of the Madras Presidency it is *Kuchu-valli Kilangu* or *Mara valli Kilangu* (white stick yam) or *Al-valli Kilangu*, by misapplication; also *Savari-kattai* quite locally.

On the Malabar Coast it is *Mara-chini* (stick sweet potato) and *Kappa Kilangu* (ship yam).

In the above pages I have reviewed what we know about the plant in India and told the races that are present for any purposes to which we can put them; now it is necessary to indicate what might be done with them.

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Cultivation and Uses. (*I. H. Burkill.*)

MANIHOT utilissima.

Description of the plant.

APPEARANCE OF THE PLANT.

Manihot utilissima is an undershrub with the growth of a castor oil plant but more rigid. Its stems are moderately thick, for the most part straight and with a large pith. Its leaves are as broad as long, cut nearly to the base into 3, 5, 7, 9 and 11 fingers, 5, 7 and 9 being the commoner numbers. The fingers may vary considerably in breadth. Their colour is a deep green above and a lighter green below, with short hairs, only when quite young. The flowers which are but seldom produced stand in short panicles among the leaves; there are both male and female flowers on the same panicle, the former smaller than the latter. The male flowers are situated above

FIG. 1.

FIG. 1A.

Leaves of **Manihot utilissima** from Tavoy and Sibsagar.

the female flowers. They are purplish green outside, reddish green within, with five perianth lobes, and with ten stamens sometimes longer, sometimes shorter than the lobes. The female flowers have the same five perianth lobes but longer, and within them the green ovary with its stigmas. The seeds are elliptic, black, shining, with a thick fleshy seed stalk. The roots are swollen, with a red brown or blackish brown skin and white or yellow flesh loaded with starch, and they contain more or less prussic or hydrocyanic acid either in the skin only or throughout the substance.

It is these roots freed from the poison in them that constitute the great economic value of the plant.

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APPEARANCE OF THE PLANT.

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When the young plant reaches a height of some five feet they are as drawn in figure 2 and later may grow to the size represented in figure 3.

FIG. 2.

Small root (after Tracy).

FIG. 3.

Very large roots from the United States (after Tracy).

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Cultivation and Uses. (*J. H. Bur ill.*) **MANIHOT utilissima.**

APPEARANCE OF THE PLANT.

Naked Eye Differences between sweet and bitter.

Races of the sweet cassava are more hardy than the bitter, but yield less in weight of roots. The tubers are smaller in these hardy races and often lighter in the colour of both skin and flesh. Semler (*Tropische Agricultur* II, 1900, p. 769) says that the leaves stand straight out from the stem or depend, while in bitter cassava they grow upwards. Dûss says in his *Flore de la Martinique* that the sweet cassava plant is more erect, its stem is not angular, its petioles are yellowish green and never brown or black as are those of the bitter cassava plant: that there are at the base of the petiole two winged stipules which in bitter cassava are only represented by traces or by a process like a prickle with a broad base: that its leaves are a little larger, less slender and less pointed in the lobes and that its fruits are without wings and slightly angular at the summit.

Probably these differences given by Semler and Dûss may hold good in particular localities, but they most likely do not hold good in any broad way.

NATURE OF THE ROOT.

The **Manihot** stores up large quantities of starch in its roots and guards it with more or less prussic acid. The greater part of this prussic acid may be in the bark of the root and the interior so free from it as to be safely eaten raw—this is in sweet cassava—or the prussic acid may occur all through the root and then we have bitter cassava.

Prussic Acid.

There are degrees of poisonousness. The most poisonous roots seem to be those with yellow fleshed and rather fibrous tubers. Death is very rapid from eating them uncooked, but their bitterness ought to warn the eater that they should be avoided. In the countries where much of the root is grown, cases of poisoning are occasional. The recognition of the nature of the poisonous principle was made long ago; but the recognition that sweet cassava may hold the same has only come about of relatively recent years. Sagot in 1871 (*l.c.* p. 349) wrote that he doubted if any kind were absolutely free from the poison. Francis in 1877 (*The Analyst*, April 1877) demonstrated the presence of prussic acid (HCN) in West Indian Sweet Cassava. These are his figures:—

	Sweet Manihot.	Bitter Manihot.
Maximum	·0238	·0442
Mean	·0168	·0275
Minimum	·0113	·0133

Carmody in the *Trinidad Agricultural Society's Proceedings* (copied in the *Trinidad Bulletin of Miscellaneous Information*, 1901, p. 319) gives the results of a further examination, in which using

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NATURE OF THE ROOT.

a slightly different method of analysis he was able to find in sweet cassava.

	Prussic acid per cent.
Maximum	·019
Mean	·010
Minimum	·005

Carmody, however, has gone beyond Francis and he shows that in West Indian Sweet Cassava it is the skin which contains the greater part of the poison, while in bitter cassava the poison is distributed more evenly through the root. His figures are published in a place little accessible to workers in India and for that reason are reprinted here *in extenso.*

CARMODY'S ESTIMATIONS.

"The following are some of the results obtained from fairly representative samples of sweet cassava :—

Inner part HCN per cent.	Skin and outer cortical layer. HCN per cent.	Inner part. HCN per cent.	Skin and outer cortical layer. HCN per cent.
0·006	0·033	0·004	0·024
0·003	0·014	0·010	0·030
0·015	0·033	0·004	0·042
0·008	0·031	0·005	0·038
0·011	0·020	0·003	0·034
0·008	0·032		

With bitter cassava the following results were obtained from representative samples :—

Inner part HCN per cent.	Skin and outer cortical layer HCN per cent.	Inner part HCN per cent.	Skin and outer cortical layer HCN per cent.
0·031	0·024	0·017	0·019
0·034	0·012*	0·019	0·020
0·021	0·025	0·016	0·024
0·037	0·014*	0·017	0·020
0·030	0·025	0·013	0·016
0·014	0·033	0·032	0·056

The general conclusions to be drawn from these results are :—

(1) that in sweet cassava the prussic acid is not uniformly distributed throughout the tuber and that in bitter cassava it is uniformly distributed, or nearly so; and

(2) that this affords an analytical means of distinguishing between sweet and bitter cassava."

* Exceptional.

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It has probably been noticed by the reader that **Carmody** contrived to extract less prussic acid than **Francis**—a result, he thinks, due to some influence of season on the plant, which unfortunately cannot be gone into here.

AN INDIAN ANALYSIS.

Dr. J. W. Leather, analysing roots from Goalpara, Assam, found in them ·015 per cent. of prussic acid.

Prussic acid ready formed and capable of being formed.

A certain amount of prussic acid exists in the root ready formed; and there exists with it also the formative materials for the production of a further amount, so that though a soaking or boiling in water may remove what is present, there is in the roots the possibility of more appearing to replace some of what is lost.

Carmody shows that how feeling unwell may result from the eating of cooked cassava by reason of this happening. He writes—

"It is shown in my experiments that whilst a first boiling removes a certain amount of hydrocyanic acid—all in fact that exists ready formed in the tuber—a second addition of water and subsequent boiling removes a further portion. It would appear from this that cassava in a person's stomach would also develop an amount of prussic acid ...... The total quantity would, however, be far below the minimum fatal dose and would only be expected to produce those unpleasant results occasionally reported."

Symptoms of poisoning.

Symptoms of cassava poisoning are violent pains in the stomach and then collapse. The treatment is to make the sufferer vomit and do everything to keep up circulation and most especially respiration.

Reason for cooking before sale.

The preventive measure to be taken is good cooking. Boiling removes the prussic acid to such an extent that the root is harmless or never fatal. Roasting removes all the prussic acid. It seems to me, however, that in India cassava is sold cooked more because cooking preserves the tuber than because it renders it innocuous.

The prussic acid in the roots has no commercial value.

Poisoning in the West Indies.

West Indian statistics shew that most of the cases of cassava poisoning occur among undercared-for children who eat the bitter root despite its taste, and in towns where it is due to careless preparation of food (*W. Indian Dept. of Agri. Leaflet* No. 7, p. 3, and *Hart* in *Trinidad Bulletin of Miscellaneous Information*, 1901, p. 323).

There has never been known a case of poisoning in Florida. Unfortunately I cannot find analyses of the roots of Florida plants which tell the amount of prussic acid in them. But I do not suppose them to be free altogether from it though probably very like the Colombian plants of which analyses follow. In Colombia these races are held quite harmless.

How much of the tuber is bark.

The bark makes up in the West Indies one-fifth by weight of the whole tuberous root.

Analyses showing prussic acid and starch, etc.

More than one-half of the weight of the fresh root is due to water and about one-third or less is due to starch. The following are the figures of analyses by **H. H. Cousins** of roots of Colombian races

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grown by Mr. R. Thomson in Jamaica at Half Way Tree. The figures are in the order of starch content and are taken from the *Bulletin of the Dept. of Agri., Jamaica,* 1903, p. 37.

Name of race.	Moisture.	Starch.	Solids not starch.	Prussic acid.
Governor Hemming . .	57·17	36·50	6·33	0·0018
Cabesa Dura . . .	54·69	35·40	9·99	0·0010
Negrita (sample No. 1) . .	55·10	34·80	10·10	0·0019
Helada (sample No. 1) . .	55·41	34·30	10·29	0·0007
Paloma	57·78	34·30	7·92	0·0017
Blancita . . .	54·22	33·80	11·98	0·0009
Pacho (sample No. 1) a hill race	59·61	33·33	7·06	0·0029
Cajon Amarilla . . .	56·11	33·30	10·59	0·0030
Negrita (No. 2) . . .	59·31	31·10	9·59	0·0010
Helada (No. 2) . . .	56·93	29·90	13·17	0·0019
Negrita (No. 3) . . .	61·43	27·70	10·87	0·0020
Cenaguera	67·21	25·00	7·79	0·0014
Montera . . .	71·42	25·00	3·58	0·0009
Negrita (No. 4) . . .	60·57	23·90	15·53	0·0035
Pacho (No. 2) . . .	58·57	22·30	19·13	0·0022
Pacho (No. 3) . . .	72·28	22·10	5·62	0·0010
Pacho (No. 4) . . .	64·19	19·30	16·50	0·0010

Analyses by Archbold.

Archbold as a result of over 100 analyses of roots from Jamaica found an average of 26·23 per cent. of dry starch to be present. The root further contained 4 per cent. of sugar. He gives the following figures:—

	Water.	Protein.	Fat.	Resins, Alkaloids.	Amides and sugar.	Crude fibre.	Starch.	Ash.	Potash.	Phosphoric acid.
Fresh root .	66·745	0·855	0·188	0·115	5·650	1·685	24·075	0·740	0·300	0·080
Dried root .	5·170	2·455	0·525	0·325	16·090	4·800	68·530	2·105	0·860	0·255

Analyses by Wiley.

The next table gives analyses made by the United States Department of Agriculture on dry roots.

	Moisture.	Ether extract.	Crude fibre.	Pentosan.	Starch.	Protein.	Ash.	Etc.
Florida .	5·47	·37	4·05	3·09	57·60	3·42	1·47	24·53
Florida .	5·11	·50	6·53	2·93	67·20	3·16	1·56	13·01
Alabama .	7·05	·49	6·06	2·43	62·19	2·37	3·04	16·37
Mississippi	5·59	·26	3·76	2·06	70·13	2·98	1·75	13·67
Average .	5·76	·42	5·08	2·63	64·28	2·98	1·96	16·89

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Analyses by Francis.

Francis' analyses of Cassava gave results as follows :—

	Moisture.	Sugar.	Starch.	Fibre.	Mineral salts.	Albumen, etc.
Sweet Cassava .	58·73	·81	33·38	2·04	·71	4·33
Bitter Cassava .	62·07	2·67	29·39	2·01	·59	3·27

Analyses of Flesh and bark.

Wiley analysed roots from Florida separating the bark from the interior with these results :—

	Peeled root.	Bark of root.
Moisture	61·30	61·30
Ether extract	·17	·66
Albuminoids	·64	2·29
Starch	30·98	...
Fibre	·88	3·83
Ash	·51	2·02
Undetermined	5·52	29·90

It will be noticed that the bark contained no starch.

DO EXTERNAL CONDITIONS DETERMINE THE AMOUNT OF PRUSSIC ACID PRESENT.

Dr. Maingay of Malacca has in the *Journal of the Agri.-Horticultural Society of India*, I, New Series, 1869, p. 191, the following sentences :—

"It is adduced by all classes of cultivators with whom I have conversed on the subject that in planting from cuttings they must on no account be inverted. If by an accident this occurs the resulting tubers do not belong to the variety described as the sweet but to that to which in the West Indies I imagine the term "Bitter Cassava" has been applied. .... With a view to test the accuracy of the popular belief I have planted six cuttings in the usual manner and six inverted. I fear my stay in my present appointment will not be sufficiently long to enable me to lay the result before the Society."

Curious as the statement reads there is not material to laugh at in it, because experiments have indicated that circumstances unfavourable to the plant do increase the amount of prussic acid present. I quote the following paragraph from the *Queensland Agricultural Journal*, XII, 1903, p. 131.

"It is indicated (by Dr. Maxwell) that the difference of sweetness and bitterness may be due to the conditions of soil and climate in which the Cassava plants are grown. This opinion of Dr. Maxwell is most conclusively borne out by the recorded experience of a Cassava planter in Jamaica who in reference to very particular enquiry regarding experiences with Cassava in that island has reported as follows :—

"Soil has a great effect on Cassava as I have seen sweet Cassava turn quite bitter on some lands; the variety called Mexico (which is

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very productive) being especially apt to change in this way. The change is generally produced by planting on a free level soil after growing on stony hilly land . . . Our bitter Cassava if planted in Central America turns to sweet."

Sawyer (*Indian Forester*, Vol. XXI, 1895, p. 291) tells us that the roots grown in Travancore in the rainy season are nicer to eat and "more wholesome" than those grown in the dry weather.

Age does not increase the prussic acid.

Carmody (*Trinidad Bulletin of Miscellaneous Information*, 1901, p. 322) says that there are no grounds for the common belief that sweet Cassava contains more prussic acid the older it is.

Uses.

USES.

The root of **Manihot** yields the following four important preparations:—

Starchy Foods.

Couac.
Cassava meal.
Brazilian arrowroot.
Tapioca.

It yields also the sauce cassareep and the Brazilian fermented drink piwarri. Couac is the coarsest roughest meal. Cassava meal is a finer preparation. Brazilian arrowroot is starch washed out of the root and Tapioca is the same slightly torrefied.

Sauce. Fermented drink.

Cassareep is made from the juice by boiling it down to the consistency of molasses; and piwarri is made by the Indian women who chew the root and spit it out into bowls to ferment.

Uses of leaves

The leaves of some races of **Manihot** are eaten as a vegetable, this is specially so in Java: and cattle seem to eat them readily without harm. But the leaves of some races are reported as being poisonous to cattle. In India a variety of insects more or less omnivorous (and therefore not specialised to digest the poison) are ready to attack the plant (vide *Shortt's Manual of Indian Agriculture*, 1885, p. 309).

Preparation of Food products in Brazil.

In making any of the four first named preparations the preliminary act is the peeling of the root and the second its disintegration. There are two processes in use in Brazil by which this is done—

(i) the interior edible part of the root is rasped on a board with metal points or on a large nutmeg grater or on a wheel with points; Neuville in the *Journal d'Agriculture Tropicale*, 1903, p. 324, describes a rude grater still in use furnished only with bits of broken pottery or glass or quartz by way of teeth. The raspings are left for twenty-four hours to ferment on a mat or cloth and are thrown damp into a bag made of rushes or canvas to have the juice squeezed out of them.

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(ii) the roots are thrown into water; peeled or not peeled, and left for some days until they are soft and somewhat slightly fermented. They are then easily crushed. If they have not been peeled before soaking the rind is removed by hand before they are crushed.

In the Brazils the expressions *farinha secca* and *farinha d'aqua* are used for the meal or flour resulting from the different ways of making it. The manufacture of *farinha secca* and *farinha d'aqua* is described in the *Diplomatic and Consular Reports*, Misc. series, 547, 1901, p. 10, and elsewhere.

Subsequent operations turn the root into couac, cassava meal, Brazilian arrowroot or Tapioca.

If couac is to be made the bag is compressed, generally by being hung with a weight pulling upon it below, and after the juice has run out, the raspings or crumbs are turned out, dried somewhat, then pounded and finally made quite dry. It seems that if not made quite dry the meal will not keep.

If cassava meal is wanted, probably the d'aqua process is used in the first operation and after compression of the bag as in making couac the last pounding is well done and the particles sifted until a considerable degree of fineness is attained. The meal is also more carefully dried over a fire with stirring.

There is a yellow couac in Brazil said by Neuville to be greatly valued, and so much so that an imitation of it is made dyed with Curcuma.

The manufacture of arrowroot in Brazil.

For the making of Brazilian arrowroot the wet process (No. ii) is preferable for we want to wash out starch and to remove the cell walls, etc. The tubers are, therefore, well macerated, crushed and the starch removed by the use of plenty of water from which it is allowed to settle.

The making of starch in Brazil has received a good deal of attention; and what with the making of Cassava starch or Brazilian arrowroot in Sao Paulo and elsewhere, and the making of starch in the province of Santa Catherina from **Maranta** the country has a large business.

The Tapioca Industry of Brazil.

The tapioca industry of Brazil is centred in the provinces of Bahia, Minas, Santa Catharina and Rio de Janeiro. Further north there is a cassava meal industry but no tapioca industry. I do not know when it took its origin. In the middle of the last century the exports from Brazil were very considerable. In 1871 according to Simmonds (*Tropical Agriculture*, 1877, p. 351) they were valued at £26,050, three-fifths of which went to Great Britain. The export subsequently decreased: but again increased till in the last decade it stood again at about the same value, while more than

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formerly is consumed in the country. The best Rio tapioca fetches the highest price in the European market. In making tapioca the starch is won as described, and dried up to a certain point, whereupon it is transferred to hot iron plates, and with gentle stirring is made quite dry. The heat of the iron plates, about 100° C., makes the wet starch granules to crack and stick together into little pellets or flakes and in these forms it comes into the market.

The Tapioca Industry of Straits Settlements.

The tapioca industry of the Straits Settlements has had a good deal more than half a century of success chiefly in the hands of Chinamen. Maingay in the *Journal of the Agri.-Horticultural Society of India*, N. S., Vol. I., 1869, p. 135, has given a brief mention of it. At the time when he wrote, Chinamen easily obtained grants of Government forest land at a very low rental, the idea of the Government being to bring this land under permanent cultivation. The lessees cleared off the forests and planted tapioca. For three years they continued cropping the land and then the soil being worn out, managed to transfer it to other parties who finding it no longer fertile let it go back to scrub and so ultimately to forest. Maingay wrote strongly upon the mischief being done.

The tubers produced weighed from 10 to 25 lbs. at the end of eighteen months when they were dug. Taken out of the soil they were first scraped and then well washed either by hand or in a rotatory drum. Next they were crushed between rollers and the pulp shaken up with water, the water strained through muslin and left for the starch in it to subside; eight or nine times after this it was washed with a view to getting it white and finally it underwent a bleaching in the sun in heaps.

Pearl tapioca was made from it by taking small quantities of the starch at a time slightly moistening it and placing it in a cradle-shaped frame lined with canvas wherein it was given a rotatory movement and granulated. The granules were next dried in the sun for a time and finally slightly torrefied by being stirred round in a hot shallow iron pan. The average amount of the export of tapioca from the Straits Settlements for the years 1862-1870 was 32,908 cwts. and value £41,453 (or R62,17,195 at the present rate of exchange).

In the five succeeding years it increased to an annual value of £73,713 (*vide* Simmonds, *Tropical Agriculture*, 1877, p. 352).

Since Maingay's time the process of **Manihot** cultivation has not materially changed, but the fields have got further and further away from the coast towns in the continued search for rich land on which to grow it. A race with yellowish-green stems is preferred to the one with reddish stem.

Factories are never far from the fields; but no longer is the trade so exclusively in the hands of Chinamen as it was formerly. As

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formerly, some of the factories have machinery for washing the roots; and some wash by hand. After washing the roots are crushed and the crushed material passes with water into a gauze bag. The stream of water running through it carries the starch forward through a long channel into masonry tanks. The stuff held back is turned down another broad channel and kept for fattening pigs. When the starch in the masonry basins has completely subsided, the water above is run off, the powder is dug out into big tubs and stirred up with perfectly clean water and allowed to subside. The process is repeated as often as is necessary until the starch is quite clean.

At this point the processes for the making of pearl and of flake tapioca diverge.

Pearl tapioca is made by taking the damp half-dried blocks of starch breaking them up and in a cloth by a jerking backwards and forwards movement making the meal to form into pellets. The jerking requires skill and upon the way in which it is done the size of the pearl depends. By means of sieves the pearls are afterwards graded and then torrefied in big ovens on hot plates.

Flake tapioca is made by taking the starch slightly damp and putting a thin layer on the hot plates stirring gently until it is torrefied enough.

The refuse sells at 6-8 dollars the cartload. (Schlechter in *Tropenpflanzer*, 1901, pp. 323-324.)

The export of pearl tapioca from Singapore in 1903 was 316,800 cwt. and in flake or flower 209,300 cwt.

Chinamen with no capital have devised a modified form of the "d'aqua" method, and succeed in making a coarse article. The process has just been described by A. L. De Mornay in the *Agricultural Bulletin* of the Straits and Federated Malay States, III, 1904, p. 133. De Mornay's note is as follows:—

"The smaller Chinese growers, not having the sufficient capital to erect steam machinery to work off their crops, discovered a method some thirteen years ago, of producing an inferior Tapioca flour, or, more correctly speaking, meal, by means of rotting the tubers in water instead of disintegration and thus avoiding the necessity of motive power.

A hole or shallow well of suitable size in proportion to the extent of crop to be treated, is dug in the ground at a spot of sufficiently low level to ensure the water remaining stagnant and not draining away. The hole is then charged full of unwashed tubers, care being taken that all are entirely submerged, and there left for 4 to 7 days. The time they take to rot depends to some extent on the weather (a low temperature retarding putrefaction) and partly on the

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degree of foulness the water may have reached according to the length of time, the same hole may have been previously employed for the purpose. A new hole with pure water, taking a considerable longer time to accomplish putrefaction.

When it is found that decomposition is sufficiently advanced to mash the tubers to a pulp between the hand, they are removed from the hole and placed in a large tub into which a man enters and treads them out to as fine a pulp as possible.

A basket of about $\frac{1}{4}$ inch mesh is placed in a separate tub, and the pulp is poured into this and stirred till the greater part passes through the meshes of the basket, leaving only the woody and imperfectly rotted portions of the root. Water is frequently poured on the pulp to assist in straining the basket. When the desired quantity of pulp has thus been treated, the basket is withdrawn and the pulp left for 24 hours to precipitate. When it has settled, as well as its fibrous nature will permit of, the water is baled out of the tub and skimmed off the flour as much as possible.

Ordinary gunnies (sacks) are then tied to sticks driven into the ground in a triangular position, and the pulpy mass removed from the tub and thrown into the sacks, where it is left to drain. In this way the water drains out of the pulp, and becomes of sufficient consistency to be removed from the sacks, separated into pieces, and spread over a cement space to dry in the sun. Whilst drying, the lumps are broken smaller, and when comparatively dry, are trodden out and finally sifted through bamboo sieves of about $\frac{1}{4}$ inch mesh, and packed for the market.

The proportion of so-called "Flour" obtainable from the tuber may be calculated at 27 to 32 per cent."

Cassava Starch Industry of the United States.

The tapioca industry of the United States is quite a new one. In 1888 it did not exist; only in Florida certain planters were in the habit of making their own starch from the root. In 1894 Wiley (*U. S. Dept., Agri. Division of Chemistry, Bulletin* No. 44), reported upon the plant, concluding that—

"Cassava can be cultivated with safety and profit in the greater part of the Peninsula of Florida, and probably also in Southern Alabama, Mississippi, Louisiana and Texas; it will yield with fair treatment on the sandy soils from 4 to 5 tons (8,960-11,200 lbs.) per acre.

"It will give when properly manufactured 20-25 per cent. of the weight of the fresh root in starch of high grade.

"An excellent article of tapioca can be prepared from the starch.

"Glucose can be prepared directly from the starch and more profitably from the pulp of the peeled root.

"The plant furnishes an excellent human food and cattle food, deficient, however, in nitrogen. It would make a well-balanced ration for cattle with one-fourth of cotton seed oil cake."

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Cassava Starch industry of the United States.

In the same year according to Tracy (*Farmer's Bulletin* No. 167, p. 7), cassava starch seems first to have become an article of trade. At that date business men familiar with the manufacture of corn starch from maize, turned their attention at once to the cassava plant. A factory was established at the town of De Land and another in the next year at Lake Mary. New races of the plant were imported, but the importation not succeeding, they have fallen back upon the already established races (*vide* p. 123 above) and the factories now both grow and buy from farmers roots for their purpose. "Both factories," says Tracy, "appear to be profitable business enterprises and it now seems probable that others will be erected in the near future. Up to the present time these factories have confined their operations to the manufacture of starch only, no attempt having been made to produce tapioca, glucose or other products. None of the starch made at the factories has been offered in the retail market, all being sold to cotton factories where it is used in making sizing for various classes of goods...".

To the farmer, who sells to the factory as a rate which the factory owners maintain is the maximum possible price permitted by the competition with other starches, the crop is, says Tracy, in his concluding remarks, "not more than ordinarily profitable except when grown on unusually favourable soil" and where the cost of carting to the mill is little. But the factories are largely increasing their acreage on their own adjacent lands.

Method of manufacture.

Robert Thomson in a Report made to the Government of Jamaica (*Report on the Cultivation of Pineapples and other Products in Florida*, 1901, p. 11), says that the Lake Mary factory was then operating for 4 months in the year and crushing 40-50 tons o roots per diem.

Dr. G. Archbold in the *Journal of the Society of Chemlcal Industry*, XXII., 1903, p. 65, describes the machinery and process which he devised for use in the better of the Florida factories. It is a modification of the manipulation carried on in making potato-starch and is able to extract 25 per cent. of the root as starch, whereas the potato-starch machinery unmodified did not extract more than 20 per cent. of the weight of the root. The process is automatic and continuous and the plant can work 100 tons in a 10-hour day. To the delivery of the starch it takes three days.

1. The roots are washed in an inclined trough with an Archimedean screw conveyor such as is used in the beet sugar industry.

2. The roots are rasped in an upright cylinder such as is used for rasping beets.

3. The pulped root falls into a separator meeting an upward current of water of such strength that it carries the lighter starch grains upwards with it and through a wire gauze diaphragm, while

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the heavier cellulose shreds pack at the bottom and are subsequently discharged by an automatic arrangement.

4. The impure starch milk at a density of 30° Brix runs by a pipe of uniform diameter down the centre of a cone, and as it finds more space in ascending again in the cone outside the pipe, the velocity of the current is lost and the starch ceases to be carried upwards by it against gravity. There are two of these cones, seven feet high, with a door at the bottom through which the part of the liquid holding starch is withdrawn.

5. The starch milk is next treated with alkali and pumped up to a higher level to the regulators. Regulators are tanks with agitators where, by the addition of water the starch milk is brought to the required consistency.

6. It then goes to shakers such as are used in the maize-starch industry.

7. There follows a washing which is almost a repetition of process No. 4, the water removing the rest of the impurities. The starch may be withdrawn from the cone from below with whatever small amount of water is desired and is pumped into a boxing tank (store tank for the next process) of Cypress wood provided with agitators to keep the granules in suspension.

8. The thick milk is run into moulding boxes with perforated bottoms and muslin lining and by means of a vacuum chamber 75 per cent. of water is removed.

9. The blocks that come out of the moulding boxes are cut up into cubes wrapped in paper and set in a kiln to dry.

It is claimed by Dr. Archbold that there is none of the loss of starch from discoloration which has been practically inevitable in the potato starch industry.

The pulp left behind at stage No. 3 is not wasted but it is to be used for the making of glucose in exactly the same way as maize refuse is. It is to be pumped into a vat with a copper worm and be raised to boiling point with water and hydrochloric acid. Then run into a closed copper convertor where it is subjected to pressure of 30 lbs. per square inch for ten minutes or thereabout. During the period of compression rapid chemical tests are done to ascertain if the conversion is complete. When complete the stuff is run off, neutralised, filtered through charcoal, evaporated down to a certain extent, filtered again, further evaporated, cooled and put into vessels. The refuse left behind at operations 3 and 6 of the starch extraction, and on the filters in the manufacture of glucose goes to the making up of an animal feed.

INDUSTRY IN THE WEST INDIES.

A company has been formed under the name of the "Jamaica Cassava Development Company" to produce starch in Jamaica

upon the same lines as the Florida factories. Its capital is £10,000, and there is a factory now at Longville, capable of turning out 150 tons of starch per annum (*vide The Agricultural News, Barbados,* 1903, p. 134, and 1904, p. 161). To make a mill in Dominica is also proposed. The making of Cassava cakes for the American market has been suggested. These are cakes to be made of the meal and put up in tins. **INDUSTRY IN THE WEST INDIES.**

In Martinique small proprietors have mills moved by bullocks or by water-power for rasping the cassava roots and means for making starch or cassava meal; actual cultivators grow the crop and bring it to the mill on the metayer system whereby the profits are divided (Dulien *in Journal d' Agri. Trop.* 1903, p. 41).

Portuguese West Africa makes some cassava meal and so do the Cape Verde Islands. In the British Colonies of West Africa, Cassava meal is the staple prison food. **INDUSTRIES ELSEWHERE**

Mauritius and Réunion have tried tapioca manufacture and so has New Caledonia. Apparently want of capital has held the industry back in all these places.

Dr. George Archbold in the *Journal of the Society of Chemical Industry,* XXII., 1903, p. 63, puts cassava starch forward as a product of the future destined to replace maize or corn starch. "At the present time the demand for maize and other cereals is advancing their value, so that in the near future they will not be available for the manufacture of starch. The manufacture of starch from maize was introduced into America over sixty years ago by Thomas Kingsford who established the Oswego Starch Factory. The superior quality of the product soon created such a demand for "corn starch" that other factories were erected in different States and to-day all are owned by the trust known as the Corn Product Company. Maize starch has its own characteristics which distinguish it from other starches. If a cheaper raw material be suggested (to take the place of maize) for the production of starch and allied products, it must yield them of the same quality. In the plant commonly known as cassava we have such a raw material." **FUTURE OF CASSAVA STARCH.**

As food, couac and cassava meal differ from Brazilian arrowroot and Tapioca chiefly in the amount of cellulose present. The difference can be well shown by citing the following analyses by Balland of samples sent to the Paris Exhibition of 1900 (*Journal de Pharmacie et de Chimie,* 1903, 1st April and 15th May). **FOOD VALUE OF PRODUCTS OF MANIHOT.**

It will be observed that to make them keep, almost all the samples of couac and cassava meal have undergone more desiccation than the samples of Brazilian arrowroot and tapioca. It will also be observed that some of the American starches and tapioca still had a little cellulose in them: and that the washing of the latter reduces

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FOOD VALUE OF MANIHOT PRODUCTS.

the small amount of nitrogenous material present and the ash, but not fats, while the percentage of starch is hardly increased.

	Water.	Nitrogenous material.	Fats.	Starch.	Cellulose.	Ash.
Couac and Cassava meal :—						
from Ivory Coast . .	9·80	1·11	0·25	85·39	2·45	1·00
„ Dahomey . . .	9·50	2·68	0·25	83·62	2·65	1·30
„ Guiana (white) . .	9·00	1·26	0·20	85·99	2·25	1·30
„ „ (yellow) .	10·70	2·05	0·25	83·10	2·60	1·30
„ Martinique . .	8·80	0·30	0·20	86·85	2·35	1·50
„ „ . .	10·10	0·45	0·40	86·30	1·25	1·50
„ New Caledonia . .	7·00	2·37	0·85	84·73	3·25	1·80
„ Cape Verde Islands .	12·20	1·38	0·15	83·77	2·30	0·20
„ „ „ „ .	13·80	1·69	0·10	81·06	3·25	0·10
Arrowroot (Starch) :—						
from the Guianas . .	13·50	1·84	0·55	83·16	0·60	0·40
„ „ „ . .	11·80	0·94	0·40	86·36	0·00	0·50
„ Cochin China . .	15·80	0·44	0·22	83·84	0·00	0·20
„ Madagascar . .	15·80	0·84	0·20	82·96	0·00	0·20
„ Réunion . . .	14·50	0·44	0·10	84·66	0·00	0·30
„ the Soudan . .	11·20	0·30	0·25	87·95	0·00	0·30
„ Ceylon . . .	13·50	1·08	0·20	85·02	0·00	0·20
„ Guatemala . . .	13·70	0·46	0·30	84·09	0·75	0·70
Tapioca :—						
from Cayenne . . .	14·90	1·38	0·45	82·87	0·20	0·20
„ „ . . .	14·10	0·77	0·45	84·43	0·10	0·15
„ Martinique . .	9·30	0·30	0·45	88·95	0·00	1·00
„ New Caledonia . .	13·80	0·45	0·15	85·20	0·00	0·40
„ „ „ . .	13·60	0·30	0·25	85·60	0·00	0·25
„ „ „ . .	12·50	0·70	0·25	86·35	0·00	0·20
„ Réunion . . .	10·60	1·68	0·40	86·82	0·00	0·50

CASSAVA AS A CATTLE FOOD.

It has been mentioned that the waste from Tapioca factories in the Straits Settlements is sold for feeding pigs and that a cattle food can be made from the refuse of starch factories in America. We now

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CASSAVA AS A CATTLE FOOD.

proceed to the use of the whole root for fattening stock. It is to be mentioned that cassava has long been grown in Mauritius as a food for stock, but the only part of the world where a large business of this nature is carried on is Florida.

Before Wiley wrote his article on cassava in 1894 (see *U. S. Dept. Agri. Division of Chemistry, Bull.*, No. 44), the roots were irregularly in local use in Florida and elsewhere for feeding cattle, pigs, poultry, etc. But, after the winter of 1894-95 had largely destroyed the Florida orange orchards, when the farmers took to stock raising and fattening, the cassava plant attracted immediate attention. Now 95 per cent. of the cassava grown in the United States is grown to feed stock (see Tracy, *U. S. Dept. Agric. Farmers' Bulletin*, No. 167, 1903, p. 35), "All kinds of stock eat it with relish and thrive upon it much better than when confined to any dry feed."

"Being so highly carbonaceous in its composition it is commonly fed in combination with bran, cotton seed meal or other nitrogenous grain feed and, when judiciously used, it is one of the most inexpensive feeds which can be grown. It is less watery than sweet potatoes (**Ipomœa Batatas**) or potatoes or turnips, while its yield is fully twice as great. One hundred bushels of sweet potatoes per acre is a fair crop, but it weighs only 3 tons, while from 5 to 6 tons of cassava could be grown on the same ground with less expense. As the roots are always fed in a fresh condition, they furnish an excellent substitute for winter pasture, and so do much to keep animals in good condition through the season of dry feed. When the crop can be grown successfully it can be made to take the place of a silo, as the feed is much more nutritious than silage, and can be used economically when one has too few animals to make a silo profitable. In nearly all cases the roots are fed as fast as they are dug, as they never fail to keep in good condition so long as they are left undisturbed in the ground where they have been grown. The roots are so smooth that if they are dug when the soil is dry they need no washing or cleaning before being fed, and no special preparation beyond cutting them into small pieces before feeding them to cattle."

Professor Tracy continues on page 24 to show that stock does very well on cassava. As to the method of feeding, it is best done by crushing or chopping the root up before giving it to the animals.

Pigs are more often fattened on cassava than cattle; and for poultry it is very largely used.

The Lake Mary starch factory in Florida finds a ready sale for the factory waste dried as a cattle food. It is not an ideal food owing to want of proteids, but may well be mixed with other nitrogenous food. This factory waste must be dried at once or it turns sour. Technically it is called bitty.

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CASSAVA AS A CATTLE FOOD.

Factory waste ought always to be a safe cattle food owing to the working that it has had; but we do not know how far it is safe out of the United States to give fresh cassava to cattle. Under the conditions of and with the races grown in Florida, cattle can be fed on the fresh chopped roots, but as a general rule means should be taken to get rid of the prussic acid by washing or better cooking before animals are allowed to touch the roots.

YIELD PER ACRE.

Yield per acre.

Satisfactorily attested yields in North America with sweet cassava, per acre.

	lbs.
1. On poor light worn soil (Tracy) . .	4,480—5,600
2. On average soils (Tracy) . . .	11,200—15,680
3. On the very best soil, unusual yields (Tracy)	22,400—33,600
4. In Mississippi, manured with 200 lbs. bone meal (Tracy)	20,160
5. In Alabama, on excellent soil (Tracy)	28,000
6. In Florida, unmanured (H. E. Stockbridge)	7,420
7. In Florida, manured heavily with acid phosphate, cotton-seed meal, kainit (H. E. Stockbridge)	12,979
8. Average crop round Lake Mary factory, Florida (Thomson) . . .	20,160

References.—*1–5*. Tracy in *U. S. Dept. Agri. Farmer's Bulletin*, No. 167, 1903, p. 21. *6 and 7*, *U. S. Dept. Agri. Experiment Station Records*, XI., 1900, p. 334. *8*. R. Thomson *Report on the Cultivation of Pineapples in other Products of Florida*, Kingston, Jamaica, 1901, p. 11.

Yields, per acre, in Tropical America which may be accepted.

	lbs.
St. Lucia, red-stemmed race (Dulien in *Journ. d' Agri. Trop.* II., 160)	8,400
St. Lucia, white-stemmed (Dulien in *Journ. d' Agri. Trop.* II., 160)	13,440
Paraguay (Semler, *Tropische Agricultur*) . . .	13,379
Jamaica, bitter cassava, not irrigated (*Journ. Jamaica Agri. Soc.*, 1899)	19,054
Jamaica, bitter cassava, irrigated (*Journ. Jamaica Agri. Soc.*, 1899)	32,664

Yield in Africa which may be accepted.

	lbs.
Soudan, (Vilbouchevitch in *Journ. d' Agri. Trop.*, II., p. 160)	13,597

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Yields in the East which may be accepted as correct, per acre.

YIELD PER ACRE.

	lbs.
1. Pondicherry (Poulain)	2,428—4,846
2. Madras	10,880
3. Cochin China (Paris *ex* Vilbouchevitch)	10,703—16,055
4. Madagascar, without manure (*ex* Vilbouchevitch)	12,754
5. Madagascar, manured (*ex* Vilbouchevitch)	25,866
6. Madagascar frequent range (Jumelle) .	13,379—44,597
7. Réunion (Jumelle)	22,298—26,758
8. Ceylon (Watt)	22,400
9. New Caledonia (Semler) . . .	22,622
10. Andaman Islands	24,200
11. Java (van Gorkom)	13,333
12. Do. do.	27,428

References.—1. in *Journ. d' Agri. Trop.* II., 1902, p. 14; 2. *Madras Agri. Dept. Rep.*, 1879, p. 44; 3. in *Journ. d' Agri. Trop.* II., 1902, p. 299; 4 and 5. *Rapport de la Commission indigene*, 1898, quoted by Jumelle in his *Cultures Coloniales, Plantes alimentaires*, p. 57; 6 and 7. Jumelle loc. cit.; 8. *Dict. Econ. Prod.*; 9. Semler, *Tropische Agricultur*, II., p. 766; 10. *Administration Report of the Andamans Islands*, 1885-86, p. 53; 11 and 12. *De Oost indische Cultures*, Supplement, p. 275.

Statements which are not accepted, per acre.

	lbs.
Calcutta (Mukerjee in *Englishman* of 28th July 1898)	38,150
New South Wales (*Agricultural Gazette, New South Wales*, II., 381) . . .	22,400—44,800
British North Borneo (*British North Borneo Herald* quoted in *Produce World*, 14th February 1896) . .	93,333
Annam (*The Planter*, Calcutta, 11th November 1899)	35,677
Florida (Semler, *Tropische Agricultur*)	66,895
New Caledonia (Jumelle, *Cultures Coloniales*, l. c.)	37,461
Brazil (Jumelle, *Cultures Coloniales*, l. c.)	89,194
Guatemala (Niederlein, *La Yuca*, 1896) .	160,550—267,582
Florida (Jumelle, *Cultures Coloniales*, l.c.)	89,600—134,400
Demerara (A. M. and J. Ferguson in *All about Aloe and Ramie Fibres*, etc., 1890)	56,000

Cultivation.

CULTIVATION.

Propagation.

Propagation is done by means of cuttings and has been so carried on for ages. Some of the kinds of Manioc rarely flower and

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CULTIVATION.

seed. Sagot says that he never, to his recollection, saw the sweet cassava or camanioc flowering in South America; and sweet cassava flowers very rarely indeed in India. Sagot goes on to say that a certain "Father Labat affirms that Manioc plants raised from seed give but poor roots. May we believe that stock raised from seed remains as vines do, for many years puny and backward, until after several successive propagations by cuttings they attain their proper vigour and height?"

Guarding against frost

Fortunately it is the easiest to grow from cuttings. When the roots are dug, the stems are to be kept for cuttings. The way in which they have to be treated depends entirely on whether any cold is likely to be experienced or not: for they are sure to be cut down by the slightest frost. If frost is likely to occur they must be buried in straw or wrapped in straw and put in a shed. But if no frost is likely to occur and the land for them can be got ready at once, they are to be cut up into short lengths and planted. If the land is not ready and the air moist, there is only moderate harm done by leaving the whole stems in a shady moist place as they are; or in drier air the ends of the stems whole may be pushed into the earth in a shady moist place where they will root and grow slowly for a time until required.

G. A. Gammie in a note sent to me says that the natives of the Darjeeling District carelessly leave the stems lying about the ground for months until the advent of the monsoon and that they take no harm.

Planting the cuttings.

Upon planting out the fields these branches are cut into lengths of four to eight inches and set in the ground at an angle of 45° with half their lengths in the soil. Rarely they fail to grow; but usually cuttings will be numerous enough to allow of two being set together along the lines at every four feet, so that if one fails there may yet be no gap in the crop. The lines should be 4 to 5 feet apart. The middle parts of the stem, not too old nor too young, generally grow most readily, a plant will yield a hundred cuttings or more.

Water.

Frost is fatal to all races of Manihot; any cold that kills Tomatoes kills them. During the first two months of the plant's growth it requires a moderate supply of water, after which many of the races are fairly resistant to drought though retarded by it.

Soil.

The soil should be rich and light. If references be made to page 144 above and to the first three figures of the tabular statement, the effect of poverty of soil on the yield is obvious. The one thing most against the cultivation of the plant is its enormous demand for available plant food. All the tropics over it has been a great crop for light virgin forest soil. In Florida it is best grown on land

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cleared from pine forest in rolling country, in Brazil on clearings, in West Africa on clearings; and in the Straits Settlements the crops are getting further and further away from the original centres as the land gets worked out. In India it is the same, too, clearings are made and it is planted in Travancore and Sikkim. CULTIVATION.

The soil of gardens always richer than that of fields is in many other places the only soil in which it is planted. Soils with very much humus in them are not good as they caused the tops to grow at the expense of the roots, and soils which want drainage are most unsuited. Ideal soils are the soils which grow sweet potatoes well.

Irrigation. Irrigation in India is generally given about Pondicherry and a little in Travancore but hardly elsewhere.

On the flat or not. Cultivation in Florida and most other places is on the flat, in the French West Indies it is sometimes on low ridges, and in St. Lucia on low mounds like a tortoise back (Dulien in *Journ. d'Agric. Trop.* II., p. 160).

Weeding. No very special cultivation is required after the crop is planted out except to keep the soil free from weeds. When the plants have grown up a little they cast shade enough to do this for themselves.

Cost. The cost of cultivation is no more than that of cotton. **Harvesting.** When the crop is ready for the harvest dig only as it is required for the tubers soon begin to rot when out of the soil. Two or three days are enough to cause a blackening unless great care be taken. Very many of the roots sold raw in the Madras bazaars are sold with rotting commencing. I believe that they are sold cooked in Pondicherry and Cuddalore more to prevent the rotting than to remove the poison.

Maturity. The time at which the crop is mature depends on the race grown. It may be seven or eight months, or even six months in one Travancore race, or it may be eighteen or more. **Times of planting and harvest in India.** In the Madras Presidency with irrigation the crop is planted in December or January but without irrigation in the end of July or beginning of August. The roots come to the markets from the irrigated lands in November. Sawyer tells us (*Indian Forester*, XXI., 1895, p. 291) that the Malayalam cultivator of Travancore puts in his cuttings in October or November, but if the rains be late he digs the crop up immature and plants again if he can irrigate with copious irrigation at the end of March. There must be for each race a period when most profitably to harvest it, to grow it beyond which is to get possibly a little heavier crop, but a monetary gain not as heavy as the land should give. The optimum periods of these races need to be ascertained by direct experiment, for we do not know them. Probably, however, for most races it is at twelve months. **Roots left in the soil.** The loss of

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MANIHOT utilissima.

The Tapioca Plant: its History, Cultivation and Uses.

CULTIVATION.

roots in the soil in digging is great if the soil be heavy, but if the roots be small and the land light there is no cause for losing a single tuber. In Mauritius, Réunion and some of the smaller West Indian islands Cassava crops are planted to alternate with sugarcane in the place of a fallow. As both crops take a great deal out of the soil, manure must be given liberally. The practice has existed for a considerable time in the first named British Colony. Cassava without manure would do much better after a leguminous crop,—a method of rotation practised in the United States.

Alternative.

In some countries maize or an unirrigated rice are grown between the Cassava plants, and return a small yield.

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G. I. C. P. O.—No. 1384 R. E. P.—26-8-1904—2,500—P. M. M.

THE

AGRICULTURAL LEDGER.

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THE AGRICULTURAL LEDGER.

1904—No. 11.

CARTHAMUS TINCTORIUS (SAFFLOWER).

[*Dictionary of Economic Products, Vol. II., C. 637—80.*]

Other DICTIONARY articles that may be consulted:

Carthamus Oxyacantha, Vol. II., C. 633; *also*

The Agricultural Ledger, 1899, No. 12; 1901, No. 12.

A digest of the correspondence conducted by the office of the Reporter on Economic Products to the Government of India.

By REGINALD ABBEY-YATES.

INTRODUCTORY.

The following pages deal mainly, if not altogether, with safflower as it exists in cultivation. They are as the title above states a digest of unpublished information from the files of the office of the Reporter on Economic Products: very little information borrowed from books has been added to it. Regarding wild safflower (**Carthamus Oxyacantha**) the reader should consult *The Agricultural Ledger*, No. 12 of 1901. It may here be added that the oil of safflower has been dealt with as an edible oil in *The Agricultural Ledger*, No. 12 of 1899, in which will be found **Professor Wyndham R. Dunstan's** valuable Report on Edible Oils used in India.

Carthamus tinctorius, *Linn., Fl. Br. Ind. III., 386; Ind. Kew.* [*I. 445.*

THE SAFFLOWER.

Vern.—*Kusum, kásumba, kar* (the seed), *barre*, HIND.; ***Kusum****, kusam phul, kajírah, darhua* (the oil), *kuthi* (thorny), *murdi* or *mundo* (thornless variety), BENG.; *Galáp machú*, MANIPUR; *Kúsam, kúrtam, kushumbha, ma, sufir, karar* (*khar, polian*=seed), PB.; *Barre, kar*, UNITED PROV.; *Bundi*, RAJ; *Kusumba, kurdai*, BOMB.; *Kusumbo* (*kabri*=the seed), GUJ.; *Kurdi, kavarhi, kasdi, sadhi* (oil plant), *kardai*, MAR.; *Kusumba*, CUTCH; *Powárí-jo-bij, kardai, kurtum* (seed), *khoinbo* (the plant), SIND; *Khardi* (oil), *kasar* (thorny), *kusum* (smooth variety), C. P.; *Karad*, DEC.; *Sendurgam, kushumbá, kushumba-virai, sendurkun*, TAM.; *Agnisikha, kúshumbá-vittu-lu*, TEL.; *Kusanbe* (*or kusambi*), *kusumba*, KAN.; *Heboo, su, hsú-wine, supán, subán*, BURM.; *Qurtum, girtum, usfar*, ARAB.; *Kazhirah, muasfir, kasak dánah*, PERS.; *Kusumbha, kamalottara, kúshumbha*, SANS.; *Kurtim*, EGYPT.

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CARTHAMUS tinctorius.

A digest of the correspondence conducted by the office of the

BENGAL. Muzaffarpur.

Two forms of the plant are met with in Muzaffarpur, Bengal, (*a*) the thorny variety known as *kuthi*; (*b*) the thornless kind called *murdi*. The first named is believed to flower earlier than the other. The flowers usually appear from the 1st of January to the 15th February. Seeds are collected in March and April. The seat of the safflower industry is Hajipur. The area at present under cultivation, however, is stated to be only one-tenth of what it was some years ago. Safflower is a crop of the cold weather, it is generally sown about the middle of October, and is usually preceded by a bhadoi crop. But when grown with opium, the land is left fallow till September. The time of sowing depends upon the amount of moisture in the land.

Subsidiary crop.

Safflower is now cultivated as subsidiary to the following crops: potato, mustard, opium, barley, wheat, linseed, and gram. Opium and safflower are said to be particularly suited to each other.

Cultivation.

Soil.—While it is reported that the plant can be grown on all soils, it is said to prefer a sandy loam, or a light soil with an admixture of sand and clay. Safflower is generally cultivated on irrigated land. A purely sandy soil is not desirable.

Manure.—No special manure is used for this crop. Opium lands are often manured with cowdung and ashes.

Ploughing.—The number of ploughings varies according to the nature of the soil; usually six ploughings suffice.

Sowing.—When cultivated as an independent crop, it is sown broadcast at the rate of 10 seers per acre; raised as auxiliary to other crops, the seeds are sown on small banks thrown up with the shovel, about an inch above the water channel. In this case between 5 and 6 seers of seed to an acre are allowed.

Irrigation.—Safflower lands are usually irrigated by means of water channels from wells.

Thinning the crop.—The plants are ordinarily grown a cubit apart. When the growth is too thick, the young plants are thinned out. On the other hand, the tops of the plants are often broken off to induce a bushy growth.

Picking the flowers.

Picking the florets.—In small holdings, this work is generally done by women and children; for a large area a picker is usually employed. The florets are plucked or nipped off with the hand. The picker receives 1 flowerhead for every 16 flower heads gathered. He is sometimes paid in corn, in which case he receives half the weight of the flowers he collects; for collecting 5 seers of florets, he thus gets as his share $2\frac{1}{2}$ seers of maize or like crop. Delay in gathering the florets until red by exposure to the sun is said to weaken the dye. Moreover, when the florets are allowed to get crisp by heat, the pod does not afford any further supply. If care be taken, three successive supplies of florets can be obtained. Picking is generally done every three days.

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BENGAL.

Weather.—A good shower before the time of flowering is generally very beneficial to the crop; heavy rains at this season are disastrous, and if followed by cloudy weather are said to favour the spread of an insect pest called *lahi.* A west wind is believed to improve the quality of the dye.

Diseases.

Insect pests.—The plant is liable to be attacked by *lahi.* These, as already stated, are thought to be induced by foggy weather. They cripple the plants and prevent the growth of flowers.

Cost of cultivation.

Cost of cultivation.—As an independent crop per acre—

	R	a.	p.
Rent of land per acre	12	0	0
Cesses	0	12	0
Six ploughings @ 10 annas	3	12	0
10 seers of seed	1	4	0
Hoeing each 4 annas	1	0	0
	18	12	0

To this must be added the cost of picking florets and collecting seed.

Yield.

Yield.—Average outturn per acre—

	lb
Flower crop	80
Seed crop	1,000

Prices.

Prices.—Safflower has largely retrograded in price. While formerly sold at 4 lbs. per rupee, the average price at present is one rupee for 12 lbs. The average value of seed is 20 lbs. per rupee. The price of safflower rises early in those months in which marriages are largely celebrated.

Cultivators consider that a constant ratio exists between the two crops of flower and seed of 1 : 16. Thus if the flower crop be a chittack ($\frac{1}{16}$ of a seer) a seed crop of one seer will be expected. (*Mr. Bhupendra Nath Gupta, Assistant Settlement Officer.*)

Dacca.

Safflower was at one time a very important crop of the Dacca district. Of the 8,448 maunds of safflower dye, valued at R2,90,655-8-6, that passed the Calcutta Custom House in 1824-25 it is estimated that two-thirds were grown in the vicinity of Dacca . . . The industry declined with the introduction of aniline dyes. Some few villages in the Nawabgunge thána are now the principal places where safflower is still grown to any extent. . . . As was the case formerly the village of Patharghata produces the dye of the best quality. . . . (*Report on Agriculture and Statistics of the Dacca district, by Mr. A. C. Sen, C.S., 1889.*)

The reader may here consult pages 292 to 295 of *Handbook of Indian Agriculture*, by Mr. N. G. Mukherjee regarding safflower in Bengal.

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CARTHAMUS tinctorius. A digest of the correspondence conducted by the office of the

UNITED PROVINCES. Cultivation.

Cultivation.—In the Western districts of the United Provinces, *e.g.*, Meerut, Muzafarnagar, Aligarh, etc., safflower is commonly raised as a fodder crop and fed to cattle before the plants begin to flower. In Cawnpur, Jalaun, and Jhansi, it is cultivated as a dye crop.

Varieties.—There are two kinds, the one thorny, the other without thorns. The latter is grown mainly for the dye and the former for its seeds from which oil is extracted. Safflower is seldom sown as an independent crop. It is usually grown along with wheat, barley, gram, and other cereals, also with vegetables, such as radish, carrots, etc. When raised with vegetables, it is generally sown broadcast, but when grown along with cereals it is sown on the borders of fields, and by the side of *barhas* or irrigation channels.

Soil.—A stiff clayey soil together with high manuring and careful hoeing and weeding are desirable. The crop is thinly sown, to provide room between the rows for weeding. The quantity of seed per acre of the two varieties of safflower (the thorny and the thornless) when sown alone is 6 and 15 seers, respectively. When grown along with other cereals only 2 or 3 seers of seed per acre, respectively, are employed.

Prices.

Price.—The price of the seeds of the thorny and the thornless varieties is R2-6 and R2-8 per maund (82·3 lb) respectively (*note furnished by the Director of Land Records*).

In response to an inquiry for recent figures shewing cropped area under Safflower, the Director of Land Records and Agriculture, United Provinces (letter No. 1607—VIII-64, dated 14th April 1904) states that as safflower **(Carthamus tinctorius)** does not form a separate heading in the annual crop returns, the area under this crop for 1901-02 or 1902-03 cannot be furnished. The Director further remarks it is very rare to find this crop grown by itself; practically all of it is sown in lines in wheat and gram fields.

CENTRAL PROVINCES.

The safflower dye industry was formerly one of some importance in the Central Provinces, but latterly has been almost killed by the large imports of cheap aniline dyes. In the Nagpur and Wardha districts a little safflower is still grown. In Chhindwara cultivation of the dye plant has almost entirely ceased, while in Seoni it no longer exists.

Cultivation.

Soil.—Safflower is grown in black or brown soil suited for wheat, it thrives best in fields which from their proximity to the village site receive a considerable supply of manure. Sometimes the fields intended for safflower are first well manured with cowdung. As a rule the crop is not irrigated. Safflower is generally cultivated as a subsidiary crop to gram, linseed or castor and in most cases along the borders of fields.

Two kinds of safflower are grown (1) the *kusum*, possessing a smooth leaf, and (2) the *kasar*, a thorny plant with a rough leaf.

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CENTRAL PROVINCES.

The *kasar* is cultivated for its oil alone. The *kusum* is grown both on account of the dye and of the oil. The seed is sown towards the end of the monsoon, and the plant begins to flower after a couple of months. An excessive or a deficient amount of moisture proves very injurious to safflower—hence in a wet year it is grown in high and in a dry year in low lying or irrigated ground.

Plucking.

Plucking.—The flowers are picked at intervals of three days in the early or late cold weather according as the plant was sown in September or December or at some time between these months. The flowers are gathered early in the morning as they suffer much damage if exposed to the midday glare after picking.

The cost of cultivation of safflower is estimated at about R12 per acre. At the present low prices the gross profits are only about R15 an acre as against R25 gained a few years back. The prospects of the industry are thus far from encouraging.

Area.

Area under cultivation.—This is shown in the following table. The figures for 1903-04 have been kindly furnished by the Commissioner of Settlements and Agriculture, Central Provinces (letter No. 3326—163, dated the 8th July 1904.

Statement showing the acreage under Safflower during 1894-95 and 1895-96 in each district of the Central Provinces.

DISTRICT.	1894-95. Rough leafed (oil plant)	1894-95. Smooth leafed (dye plant)	TOTAL.	1903-04. Rough leafed (oil plant)	1903-04. Smooth leafed (dye plant)	TOTAL.
1	2	3	4	5	6	7
	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
Saugor	15·07	...	15·07	·10	·20	·30
Damoh	Not produced.					
Jabalpur	Ditto.					
Mandla	227·03	...	227·03	97·59	...	97·59
Seoni	430·73	...	430·73	424·15	...	424·15
Narsinghpur	...	15·03	15·03	·61	·08	·69
Hoshangabad	Not grown for some years.			3·32	...	3·32
Nimar	0·10	...	0·10	·23	·52	·75
Betul	56·88	...	56·88	60·27	...	60·27
Chhindwara	...	224·35	224·35	120·01	25·08	145·09
Wardha	21·33	3·27	24·60	10·42	46·02	56·44
Nagpur	...	127·53	127·53	8·34	...	8·34
Chanda	Not produced.					
Bhandara	71·46	0·96	72·42	68·85	·15	69·00
Balaghat	Not grown.			75·40	...	75·40
Raipur	241·36	914·14	1,155·50	896·66	1·96	898·62
Bilaspur	8,234·00	...	8,234·00	8,687·00	...	8,687·00
Sambalpur	1,232·32	...	1,232·32	1,880·09	...	1,880·09
TOTAL	10,530·28	1,285·28	11,815·56	12,333·04	74·01	12,407·05

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CARTHAMUS tinctorius. A digest of the correspondence conducted by the office of the

PANJAB. Hoshiarpur.

From Hoshiarpur, Panjáb, it is reported that the area under cultivated *kasumba* (Carthamus tinctorius) has diminished considerably since the introduction of aniline dyes. These may be said to have driven the indigenous product quite out of the market. It is noted on page 186 of Volume II, Dictionary of Economic Products, published in 1889, that the area under cultivated safflower in the Gurshankar Tahsil of this district was 6,722 acres. The figures of 1895-96 for this same tahsil show an area under *kasumba* of 1,624 acres only, or less than a quarter of what it was fourteen years previously.

Cultivation.

Kasumba is sown broadcast as a subsidiary crop, along with wheat, gram, barley, and *masar*. It is sometimes raised as an independent crop. The plant prefers a light sandy soil, especially in the hilly slopes. In the plains a land well ploughed is considered best.

No irrigation is required nor does the land receive any special preparation. A single weeding in the month of December is considered sufficient. The winter rains of December and January do the crop no harm, but subsequent rains are liable to damage the flowers. The custom prevalent in Bengal of snipping off the central bud with a view to bring about a more bushy growth is quite unknown in this district. The flowering begins about the last week of March, and is fairly established towards the middle of April. Each flower head is picked three times, the second pickings having the greatest value as they contain the most colour. Plucking is done on alternate days.

Hoshiarpur.

Insect Pests.—The plant is attacked by an insect known locally as *tela*, which also does damage to mangoes and sugarcane.

Cultivation.—In 1895 the total area under cultivation in each tahsil and for the district was reported to be as under—

	Acres.
Hoshiarpur	80
Garhshankar	1,624
Dasuya	5
Una	690
	2,399

The following figures recently received show that the cropped area under safflower in the Hoshiarpur district has still further receded :—

Total area under safflower (Carthamus tinctorius) *in the Hoshiarpur district during the year 1902-03.*

Tahsil.	Area sown in acres.
Hoshiarpur	8
Dasuya	...
Garhshankar	504
Una	146
	658

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PANJAB.

Yield per acre of cultivated *kasumba*—

	R	a.	p.
Flowers 16 seers at 4 seers per rupee . .	4	0	0
Seed 3 maunds at R2-6-9 a maund say . .	7	4	0
TOTAL .	11	4	0

Deducting half as cultivator's share, the owner's share is R5-10 and with R1-8 further deducted for revenue, a net income of R4-2-0 per acre is arrived at (*Mr. Kesho Das, Revenue Assistant*).

Ambala.

About Ambála the crop is sown in September at the rate of 13 lbs. to the acre. The plant flowers in the beginning of April. The flowers are plucked by hand in such a manner as not to interfere with the seeds which remain in the pods. About 15 or 20 days after the removal of the flowers, the seeds are gathered, and if not perfectly dry, they are placed in the sun. The yield of flowers for dye per acre is 78 lbs. and of seed 5 cwt. 16 lbs. The same plants yield both dye and oil (*Deputy Commissioner, Ambála*).

SIND.

In Sind safflower is sown in October, November and reaped in March. The land is first ploughed three or four times, it is then harrowed and the safflower seed sown like wheat. When the crop grows up and bears pods, the flowers are plucked with the fingers. The process of plucking is carried out thrice.

Only one cultivated form of the plant is recognised locally. It was formerly grown for the oil and also for the dye, but since the introduction of cheap European dyes, it has ceased to be cultivated to any extent. The yield of oil seed per acre is from 30 to 40 seers. The price per cwt. of seed is R10-4. In 1895 the production was reported to be small and local: in 1902 the cultivation is stated to have been *nil.*, *conf.* p. 158.

Conf. p. 158.

BOMBAY.

Two forms are cultivated in the Bombay Presidency—(*a*) the yellow flowered thorny variety of the Deccan, grown only for its oil-seed; (*b*) a less spiny or nearly spineless form, with reddish orange flowers cultivated in Gujerát as a dye and also for its seed.

Cultivation.

The dye plant is grown almost exclusively in the rich alluvial soils of Northern Gujerát, and on similar land in the Baroda territory. The fields intended for this crop are fallowed very carefully during the monsoon, and are liberally manured. It may be questioned whether the careful tillage does not develop the red dye matter in the flowers, and it is quite possible that the Gujerát plant, owing to this high cultivation, has become less spiny.

The plant in Gujerát or the Deccan grows to a height of about 18 inches to 2 feet. It is usual to nip off the leading shoot from each

BOMBAY. Cultivation.

plant to encourage lateral branches and the formation of a larger number of flower heads.

In Gujerát the name *kabri* is given to the seed. The crop is called *kasumbi*, and the petals prepared for dye *kasumba*. In the Deccan the Maráthi name *kardai* is given to the seed or the crop.

In the year 1895 safflower stood first amongst the oilseed crops of the Presidency with an area of over 500,000 acres annually. The chief centres of cultivation are Sholapur, Ahmednagar, Poona, Bijapur, and Belgaum. As a dye plant it is grown sparingly in the Karnatak as well as in Gujerát. In the Deccan safflower does best in black soil. It is almost always grown as a row crop with rabi *jowari* (**Andropogon Sorghum**) dry crop, wheat or gram (**Cicer arietinum**). It often occupies the headlands of cereal fields as a protection because cattle do not care to trespass through it on account of the thorns or spines. As a subordinate crop with *jowari* or wheat, three adjacent rows of safflower alternate with 12, 15, or 18 rows of the principal crop.

The rows of the principal and subordinate crop are the same distance apart, *viz.*, about 12 to 14 inches. The seed is drilled in September or early in October; 5 lbs. *jowari* and 1 to $1\frac{1}{2}$ lbs. of safflower is an ordinary seed rate. The crop will succeed best if the field has been carefully prepared during the monsoon, but it is exceptional to plough black land in the Deccan oftener than once in three years. If the field is not ploughed, the heavy harrow is used once or twice before the rains, and once a month during the monsoon up to September. No manure is ordinarily applied. The crop may be once bullock-hoed, but if the field has been well harrowed during the monsoon, weeds are not likely to appear in the rabi season and weeding is not required. If rain falls after sowing, the surface soil should, as soon as it dries, be stirred by the bullock hoe. Safflower ripens in March. The crop is ready for harvest when the plants turn yellow. It is reaped or uprooted and lies in small loose heaps in the field for a few days. The seed is then separated with a flail or long bent stick. It is difficult to give even approximately the outturn of oil seed from a row crop. The result of a crop-test taken in the Ahmednagar district in 1890-91 is tabulated below, and is nearly average :—

	Jowari.	Safflower.
	lbs.	lbs.
Seed rate per acre	4	1
Outturn per acre grain and seed	664	96
Value per rupee	55	43

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BOMBAY.

A special test taken in 1895 resulted as under. The crop was a row crop with *jowari*. Three consecutive rows of safflower as usual grew together. The distance between the rows was accurately calculated and checked by measuring the distance between the coulters of the drill used. Each strip of safflower was held to occupy an area of three times the distance between the rows or the coulters of the seed drill. The crop from more than an acre of ground (according to the above data) was tested and yielded 464 lbs. per acre. The seed was worth at the rate of one rupee per 35 lbs. (*Mr. James Mollison.*)

For further particulars regarding the plant as it occurs in the Bombay Presidency the reader may consult Mr. J. Mollison's *Textbook of Indian Agriculture*, 1901, Vol. III., pages 98 to 101.

Baroda State. Petlad Taluka.

Soil.—In Baroda safflower is grown on both clay and sandy soil; a medium loam is considered the best. Safflower is a rabi crop, and is best raised on land that has been fallowed during the monsoon. It matters little what crop has been cultivated in the previous year, but after safflower, kodra and cotton (usually *kahnami*, *i.e.*, the cotton of the Kahnam—the black soil district round Broach) or *chino* (**Panicum miliaceum**) and cotton are always grown. During the monsoon, land intended for safflower is ploughed and harrowed frequently. It is ploughed eight times with the light two bullock plough of Gujerát (*hal*) and harrowed four times. But this of course depends on the season, and on the opportunities the cultivator has for working the land. The object of the cultivator is to make the soil soak up as much rain water as possible during the monsoon, but the field at seed time should be smooth, friable, and comparatively dry near the surface. The seed is sown by drill in the end of September or the beginning of October, whenever the ryat thinks that the rains have ceased. The rows are about 18 inches apart. About 15 lbs. of seed are required to sow an acre and with the safflower 1 lbs. of castor-seed is usually mixed. Safflower seed should not be buried more than two inches deep. Before sowing, the land gets 15 to 20 cartloads of cattledung per acre, or failing this sheep are folded on the land instead. When it can be had sheepdung is considered the best. Should rain fall after sowing, the land is bullock-hoed, otherwise no after cultivation is required. (*Note by Mr. B. C. Shah.*)

From the annual report of the Department of Land Records and Agriculture, Bombay Presidency, for 1901-02 we learn that there was an aggregate increase . . . in safflower of 48 per cent. [in the area cropped] . . . still in very large defect of the acreage

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CARTHAMUS tinctorius.

BOMBAY.

Extent of cultivation.

in ordinary years. The extent to which the safflower plant is cultivated in the several districts is shown by these figures :—

	District.	Dye crop (*Kasumba*). Area in acres.	Seed crop (*Kardai*). Area in acres.
A.	Bombay Presidency Proper—		
Gujerát	Ahmedabad	1,362	981
	Kaira	1,646	828
	Pánch Mahâls	...	...
	Broach	3	...
	Surát	...	...
Deccan	Khandesh	3	1,492
	Násik	...	10,096
	Ahmednagar	...	88,094
	Poona	...	48,159
	Sholapur	...	72,721
	Sátára	...	15,492
Karnatak	Belgaum	...	29,102
	Bijápur	.	48,952
	Dharwar	...	38,461
Konkan	Thána	...	...
	Kolaba	...	6
	Ratnágiri	...	...
	Kánara	...	
	TOTAL	3,014	354,384
B.	Sind cultivation	*nil.*	*nil.*

Conf. p. 155.

Baroda.

Cloudy * weather during growth and moderate cold are in Baroda said to favour flowering and seeding, but frost is very injurious. Harvest begins in January and continues throughout February, the flowers being picked every fourth or fifth day. More than a dozen pickings are made during the monsoon. The flowers are collected in the early morning (picking must cease before 10 A.M.). In the evening the flowers gathered in the morning are roughly pounded in a mortar and sifted to prevent them from adhering to each other. The sieve is a charpoy (bedstead) covered with a network of string. On the 2nd and 3rd days the pounding and sifting processes are repeated. On the fourth day the flowers are thoroughly dried by being spread out in the sun. They are once more pounded and placed in a sack ready for use. Occasionally they are moistened with sesamum oil before being stored, but the practice is not recommended. From the first to the sixth picking, the quality of the flowers improves, after that the quality falls off, the colour of the petals becoming less bright.

After the petals have all been picked, the plant is allowed to become dead ripe, the crop is then cut and the seeds are separated by beating on a wooden board.

* "This is very doubtful. I should rather say cloudy weather was harmful"—J. Mollison.

The seed harvest usually takes place in the beginning of March. A very good crop is expected to yield 1,600 lbs. of seed and 150 lbs. of dry (four times this quantity of fresh) flowers per acre. **BOMBAY.** **Baroda.**

The safflower crop in Gujerát is, however, liable to injury from many causes. Rain after sowing is practically fatal. It is not often that a full crop is harvested. The following figures obtained from results on the Nadiad Experimental Farm may be taken as average :— **Gujerat.**

Outturn of seed per acre. lbs.	Outturn of dry flowers per acre. lbs.
973	113

Seed sells at 33 to 40 lbs. per rupee, and dry flowers at 7 to 8 lbs. per rupee. The produce is mostly exported, but a small amount of both the oil and the dye is prepared locally. (*Mr. B. C. Shah, Agricultural Officer.*)

In a recent letter, Dis. No. 461, dated the 18th April 1904, the Deputy Director of Agriculture, Madras, states :—"The crop is grown to some extent in the Bellary and Kurnool districts as a late crop on black cotton soil, but I never saw a field of safflower, though occasionally when the sorghum, amongst which it is usually sown, fails or is poor, the safflower makes a fair show. The crop is most generally grown in narrow strips along the margins of the fields as an obstacle to cattle straying off roads and paths among the sorghum crops. . . . . The total crop is, I believe, unimportant, though besides the localities mentioned, safflower plants may be seen in many parts of the country." **MADRAS.**

Leaves of **Carthamus** are eaten largely as a vegetable in Burma, and may be readily bought in the bazaars in January and February. **BURMA.** *Conf. p. 172.*

The Deputy Commissioner of Minbu reports about 3 acres cultivated in his district. The plant flowers in March. **Minbu.**

In Thayetmyo one variety only is stated to be grown for purely local consumption and that to a small extent. **Thayetmyo.**

From Henzada it is learned that only one variety is cultivated during the cold season. In this district the safflower plant cannot be transplanted : this has been tried. The flowers are used for extracting a red dye. **Henzada.**

One variety only is cultivated in Kyauksé and that for its leaves. The area under safflower is infinitesimal. The seed is generally sown broadcast in October and November, and the seed for the next year's use is gathered in February and March. The Burmans never at any time crushed the seed for oil. Formerly, before imported dyes became cheap, a dye used to be extracted from the flowers, and the area under safflower was much larger. The practice of extracting a dye from the flowers, it is reported, has now entirely ceased in this district. **Kyaukse.**

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BURMA.

Northern Division. In the Northern Division the cultivation of safflower is limited to garden plots near a few towns and is infinitesimal in amount with the exception of Mandalay where, however, it is not grown to any extent.

Central Division. Central Division. Cultivated only in the Ava Sub-Division, Sagaing district, the annual outturn in good years being about 25 baskets (225 gallons).

The Oil.

BENGAL.

Dumraon. *Yield.*—In Dumraon, Bengal, the best kind of seed yields 30 per cent. of oil.

Uses.—It is employed by the inhabitants as a lamp-oil. It is also applied as a preservative to leather buckets used for drawing water from wells. A bucket so treated will last, it is said, over a year; moreover it is stated that rats will not touch it.

Dry Hot Extraction of oil.—An ordinary sized earthen vessel is puddled all over with mud to the thickness of about $\frac{1}{3}''$ and well dried in the sun. The seed is then put in the vessel, and the latter placed upon the "oven." The vessel is then covered with cow-dung cakes which are now set on fire. The oil falls through a hole at the bottom of the vessel into a smaller vessel placed below in the middle of the "oven" to receive it.

Muzaffarpur. The seed is known in the Muzaffarpur as *Barret*, and the oil as *Barre ka tel*. The oil may be extracted cold and dry in the following way. The husks are carefully removed by pounding the seed in a mortar. The seeds are then crushed in an ordinary oil mill. Four seers of seeds will give two seers of unhusked material and one seer of oil. The oil-cake constitutes a good cattle fodder.

Or else the oil which is then locally called *jerna-tel*, may be obtained thus :—

The husks of the seed are not removed as in the cold dry process. A hole is dug and a vessel put into it to receive the oil. Above this is placed an earthen jar full of unhusked seeds. On the mouth of the jar is placed an earthen cup or plate secured with mud paste (*chikna matti*). A hole is now bored in the centre of the cup. Pieces of wood or cowdung cakes are strewn over the bulb of the inverted jar and set fire to. If the jar is very full, oil begins to drip in a few minutes. The yield of oil by this process is greater than that by cold method, being 10 chittacks of oil per 2 seers of seed. Yield by ordinary method 7 or 8 chittacks of oil per 2 seers of seed.

Calcutta. A sample of safflower seed oil prepared by a Calcutta firm was examined by Mr. D. Hooper, Curator, Indian Museum, Industrial Section, who reported as follows :—"The oil has a specific gravity of ·9224 at 15° C, a yellow colour and possesses pronounced drying

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properties. It readily saponifies with alkalis, forming a fairly good soap, and the free fatty acids have some of the characters of linoleic acid obtained from linseed. The oil-cake retains 11·55 per cent. of the natural oil and is not contaminated with any earthy impurity. The nitrogen amounts to 3·19 per cent. which is equivalent to 19·94 per cent. of albuminoids. This is not a very rich oil-cake, and the large proportion of fibrous matter is liable to detract from its value as a feeding substance for stock. It would, however, form a useful manure for many indigenous crops."

UNITED PROVINCES.

In the United Provinces the outturn of oil-seed per acre of the thorny and the thornless varieties is given at 5 and 4 maunds respectively. The yield of oil from the two varieties if extracted by the ordinary cold dry method is 20 and 22 per cent., respectively. This method of extraction consists in the removal of the husk and the pressing of the kernels in a mill. The hot dry process is not known in these Provinces.

CENTRAL PROVINCES.

Central Provinces.—The oil is extracted from the seeds which are gathered in the case of the *kusum* from the same plant of which the flowers have been collected for the dye. The *kasur* variety of safflower yields more seed than the *kusum* and the seed of the former contains more oil than that of the latter in the proportion of 5 to 4. The oil is extracted by either the dry cold or the dry hot method. The oil expressed by the dry cold method is used for culinary purposes as well as for lamps. Before expression the safflower seed is usually mixed with the *jagni* (**Guizotia abyssinica**) seed, which yields about 30 per cent. weight in oil as against 20 per cent. in the case of safflower. The oil extracted by the dry hot method is used to lubricate the axles of carts and as a salve for sores on cattle.

PANJAB. Hoshiarpur.

In the Hoshiarpur district of the Panjáb the oil is usually expressed just after the rains—September and October—when the husk is damp and can be easily separated from the seed. Very little oil is extracted in a pure state. It is the practice to mix the seed with rape seed, and extract the oil for burning purposes. In this way the cake finds a use; the pure cake is valueless as fodder, and if given to milch cattle, it dries up their milk. The oil cannot be used alone for culinary purposes. The only form in which it is offered for sale is when as an adulterant in *ghi*; it has no smell and hence cannot be distinguished from that article. Food prepared in pure oil of *kasumba* is considered indigestible.

Ambala.

In Ambála the oil is extracted by the hot dry process; the yield is equal to $\frac{1}{5}$ of the weight of the seeds including husk. The seed

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sells at R2-10-8 per cwt. and the oil at 10 lbs. per rupee or annas 14-6 per gallon.

SIND.

Sind.—The yield of oil to ascertained weight of seed by cold dry expression—the only process adopted in Sind—is 20 seers of oil to $4\frac{1}{2}$ maunds of seed.

BOMBAY.

Practice in Bombay.—Oil is expressed (without heat) either in the common country wooden mill or in a stone mill. In either case the pressure is applied by a pestle working in a mortar. The seed pressed in the wooden mill is previously husked and sifted in the same way as in Gujerát, whilst in the stone mill the unhusked seed or fruit is used. Water is added to the half crushed seed in either mill, the object being to facilitate the separation of the cake. Oil flows from the stone mill into a receiver as the pressing proceeds. In both mills the cake consolidates by the action of the revolving pestle into a thick layer against the sides of the mortar, and is removed in pieces by means of a short crow-bar. In the wooden mill the oil sinks to the bottom of the mortar, and is removed by soaking it up in a mop and squeezing out the oil with the hand. The results by each process were as under :—

	Weight of unhusked seed.	Water added to half crushed seed.	Oil.	Cake.	Loss.
	lbs.	lbs.	lbs.	lbs.	lbs.
Stone mill .	266	20	53	228	5

	Weight of unhusked seed.	Weight of kernels.	Water added.	Oil.	Cake.	Loss.
	lbs.	lbs. oz.		lbs. oz.	lbs. oz.	lbs. oz.
Wooden mill .	44	26 12	8 oz.	9 8	15 0	2 12

Baroda State.

Petlad Taluka.

In the Baroda State (Petlad Taluka) cold pressure only is employed. In obtaining the oil the seeds (fruits) are bruised between mill stones set wide apart to remove the husks which are sifted from the kernels by hand by means of the "sup" (scoop). Oil is expressed from the cleaned seed, and sells at about 6 to 8 seers per rupee.

The following results were obtained in expressing oil from the seed of the dye-plant—in a test made at Poona from seed obtained from Kariad ;—

Weight of unhusked seed.	Water added to half crushed seed.	Cake obtained.	Oil obtained.	Loss.	REMARKS.
lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	
10 0	14 4	96 14	13 0	4 6	The low percentage of oil is striking if comparison be made with that from the seed of the oilplant of the Deccan.

(*Note by Mr. B. C. Shah, Agricultural Officer.*)

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BOMBAY.

In submitting the following analyses of Deccan safflower seed and cake the Agricultural Chemist to the Government of India made these remarks:—

"Columns 2, 3 and 4 in Statement I. exhibit the composition of the seed and of the two sorts of cake (decorticated and undecorticated) at the time the analysis was made.

Both samples of cake dried very considerably before they were analysed and I have therefore calculated from the analysis, what the composition was at the time the seed was crushed. These are exhibited in columns 5 and 6.

If from these analyses and the figures relating to the experiment supplied to me by Mr. Mollison the actual weights of oil in the cake be calculated, the figures in Statement II. are obtained and there was apparently a very considerable loss of oil experienced during the experiments. Of course when operating on small quantities losses such as this are generally unavoidable, but in the case of the experiment with undecorticated seed in which 266 lbs. of seed was crushed I should not have expected it to be so great. Mr. Mollison intimated to me in his demi-official letter of 7th May 1895 that he would later send samples of the Gujerát seed and cake, and I shall feel much interested to see what the results are and to know if the apparent loss of oil can be accounted for in any way."

STATEMENT I.

	Composition at time of analysis, Safflower cake.			Composition at time of crushing Safflower cake.	
	Safflower seed.	Undecorticated.	Decorticated.	Undecorticated.	Decorticated.
1	2	3	4	5	6
Moisture	7·49	8·79	8·49	22·47	22·13
Oil	31·84	9·84	9·80	8·36	8·44
Albuminoids	13·31	16·06	32·75	13·65	27·86
Carbohydrates	18·66	27·23	21·19	23·15	17·94
Woody fibres	26·31	33·83	20·17	28·76	17·76
Ash	2·39	4·25	7·60	3·61	6·47
Nitrogen	2·13	2·57	5·24	2·18	4·47
Sand	None.	0·95	4·00	·81	3·40

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ANALYSIS BY DR. LEATHER.

STATEMENT II.

	Undecorticated.	Decorticated.	
	lbs.	lbs.	oz.
Total oil in seed	85	14	0
Oil extracted	53	9	8
Oil in cake	19	1	4
Loss	13	3	4

Analysis of Safflower seed and Safflower Cake from the Gujerát Plant.

	332 Safflower seed.	333 Safflower cake.
Water	7·92	23·88
Oil	28·85	7·68
Albuminoids	12·25	11·94
Carbohydrates, etc.	17·39	22·30
Woody fibre	31·11	31·12
Mineral Matter	2·48	3·08
	100·00	100·00
Nitrogen	1·96	1·91
Sand	·35	·42

Dye.

BENGAL.

In Bengal the mode of preparing the dye is very simple. After collection the florets are placed in a *denra* (basket), and left to dry in the shade. Exposure to a strong sun greatly weakens the dye. When sufficiently dry they are deposited in an earthen jar. Should the collection be large, the florets are usually kept in a *kothi* (a reservoir made of mud). When required for dyeing, the florets are placed in a mortar, *okhi,* and pounded, being freely sprinkled with water during the process. When sufficiently bruised, the florets are put in a cloth suspended on four poles, water is then poured on them until the yellow is removed. This stage is locally known as "*piri giryou*" (freeing the dye stuff from the yellow). Another process. On the florets being gathered in, they are bruised in a mortar or rubbed between the palms. They are then put in a *denra* (basket) and water is applied to them till the soluble yellow is removed. They are next rolled up and placed between leaves of the castor oil plant in the form of cakes. On the following day the flower cakes are opened out on a *chitai* (mat) to be dried. When they are sufficiently

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dry, they are preserved in an earthen jar or *kothi*. Sometimes the yellow is removed simply by squeezing the florets (previously sprinkled with water) with the hands. This process of removing the yellow is repeated at the time of dyeing the fabric. After the yellow has been carefully removed, the florets are rubbed between the palms with *saji* (Potassium Carbonate). In the case of a large collection, the florets are usually again ground in a mortar along with *saji* (2 chittacks of *saji* to one seer of safflower). Or, the florets and the *saji* are trampled under foot to mix them completely. The *saji* is generally prepared from the ashes of plantain stems or from the ashes of *tár* palm or *khajar* (date palm) leaves. After the *saji* has been thoroughly mixed with the flowers, the latter are strained through a cloth. Three strainings are generally taken. The first is for dyeing crimson red, the second for obtaining a lighter colour, and the third for a lighter still. Into the three mixings which are kept in three separate vessels, acid is put. Tamarind, lemon, mango, *dáhi* (curded milk) are employed. In some localities the 2nd and 3rd strainings are not acidulated. To a seer of strained material, 4 chittacks of tamarind and mango are allowed.

A large number of colours is produced with safflower as their basis. Again different shades of red are produced simply by regulating the period of immersion in the strainings. The principal colours produced from safflower are (1) *lal* (red) or *ekranga* obtained by dipping the fabric in the 3rd, 2nd, and 1st straining. (2) *gulabi* (pink) by immersing the cloth in the 3rd and 2nd straining only. (3) *baigni* (purple) is produced by first dyeing the fabric in indigo and then in safflower. (4) *surmai* (antimony black) is obtained by dipping first in indigo and then in safflower, (5) *badami* (almond colour) is produced by treating the fabric first with a preparation of *singhra* (**Nyctanthes Arbor-tristis**) and then safflower dye. (6) *kesarya* (saffron yellow) is got by immersing the cloth in a preparation of *dhawa* (**Anogeissus latifolia**) and thereafter in safflower dye. (7) *narangi* (orange yellow) is produced by dipping the fabric first in the yellow and then in the red dye of the safflower. (8) *champa* (orange) a ground colour is first given by turmeric, the fabric is then dyed with the red dye of safflower.

As with indigo much depends upon the care taken in preparing the dye stuff and in dyeing the fabric. The superiority of Tirhut or Bengal indigo over North-Western Provinces indigo is due perhaps more to the greater care bestowed upon preparation than to soil or atmosphere. It is believed that the older the safflower, the better colour will it afford.

The passages which follow deal with the safflower industry as practised in Behar, Bhagalpur, Dinajpur and Purnea in the earlier part

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of the last century They are taken from *Montgomery Martin's History, Antiquities, Topography and Statistics of Eastern India*, 3 volumes, London, 1838.

Behar and Patna.

Kusum or safflower is cultivated to a considerable extent; 1,500 bigahs are sown with this alone, and a great deal is scattered through other crops, especially in rows round poppies, and round vegetables for the kitchen. [*Behar and Patna Districts in Martin's Eastern India*, I., p. 292.]

Bhagalpur.

The dyers in most parts of the district [Bhagalpur] are chiefly employed to dye the clothes of those who attend marriage parties, that are exceedingly numerous; and during the three months which the ceremonies last, the dyers make very high wages; but at other times they have little employment. They dye chiefly with the safflower, with which they give two colours, *kusami*, a bright pomegranate red, and *golabi*, a pale but fine red like the rose; and each colour is of two different shades. . . . As the dyeing cotton with safflower, and the other flowers is much practised at Mungger [Monghyr], I shall give an account of the processes as they were performed before me. The safflower, **Carthamus tinctorius**, or *kusum*, is in most demand.

In order to dye the pomegranate red (*sorukh* or *kusami*), for three turbans 40 cubits long by 1 wide, take of the flowers 3 sers (84 S. W.)* or 6 lbs. 7½ oz., value Re. 1; of impure carbonate of soda (*saji*), 6 chhataks, almost 13 oz., value ½ anna; of turmeric 1 chhatak 2⅙ oz., value ¾ anna; of any vegetable acid, lime-juice, mango, or tamarind, to the value of ¾ anna. Wash the flowers on a cloth strained with six pots of water, each containing about 15 sers (32 lbs. 5½ oz.) until the water comes off clear. This water is called *pili*, and is used in dyeing green with turmeric and indigo. In about an hour after, wash the same flowers with another six pots of water. This water is called *dohol*, and is of no use. Then squeeze the water from the flowers, add the soda, and rub them together.

Then place them on the strainer, and with 1 or 1¼ pot of water wash out the colour, which is called *sahab*, and is the proper dye. In this dip the three turbans, and knead them in the dye. Then take out the cloth, and add the turmeric and acid; then put in the cloth again, and having soaked it, wring, and dry it in the shade. The same operation is repeated with fresh flowers on the two following days. If the colour is wanted lighter, a little more water is added to the *sahab*; and if a bad cheap colour is wanted, give the cloth only one or two dips instead of three.

* Sicca weight. Thus 84 S. W. implies that in the locality mentioned the seer in use weighed 84 tolas.

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The best *golabi* or rose colour is given thus. After having extracted the *sahab* colour as above, the dyer adds to the same flowers another pot of water, which extracts a colour called *Pachuya,* that dyes four turbans of the same size. They are first dipped in the dye, then taken out and an acid added, and then dipped again and dried in the sun. Each turban brings to the dyer 2 annas, and the acid costs $\frac{3}{4}$. A paler rose colour is given by taking $\frac{1}{4}$ ser of the *sahab* colour, adding 5 sers of water, and using this dye as the other. The dyeing three turbans of a bright pomegranate brings the dyer R4-8 as. and the four turbans of a rose colour brings 8 annas, in all R5. The cost is R3-6$\frac{3}{4}$ annas.

Naranggi, or orange colour and *zurd*, or yellow, may be given either with the flowers of the *Singgarhar* or of the *Tunyd*, both nearly of the same quality, and used in the same manner; but each turban requires 4 chhataks (8$\frac{2}{3}$ oz.) of the former, while 6 chhataks (13 oz.) of the latter are necessary. The flowers are boiled in 3 sers (each 2 lbs. 2$\frac{1}{2}$ oz.) of water to 2 sers. When cooled, add 1$\frac{1}{2}$ ser of the *sahab* colour, prepared as above from safflower, and 1 ser of water. In this dip the cloth, wring it, add some vegetable acid, and soak the turban in the mixture for 24 minutes; then wring and dry it in the shade. This makes an orange of different shades according to the quantity of cold water added. Each turban pays for dyeing 4 annas. The yellow colour is given in the same manner, only that no *sahab* is added, and that in place of acid 1 chhatak of alum, worth $\frac{1}{2}$ anna, is employed. The flowers are boiled with 4 sers of water to 3 sers. If a light yellow is wanted, a little cold water is added to the dye when cool. *Martin's Eastern India*, II., 267-269.

Dinajpur.

Plants cultivated for dyeing.—The plants cultivated in the fields of this district (Dinájpur) for producing dyes are two, indigo and safflower. The last is of little or no importance, and a few drills of it are occasionally put amongst cotton, as I have already mentioned, or a small bed is sown in a garden, chiefly on account of its leaves, which are used as a green. The safflower is chiefly used at Maldeh, and the greater part is imported from other districts. The natives here do not eat the seed. *Martin's Eastern India*, II., p. 866.

Mal eh.

Dinajpur.

Two colours are given with safflower (**Carthamus tinctorius**), and are called *kusum* and *golabi*. The *golabi* is a fine rose-red, but is not a fixed colour. For one skein of silk take 10 S. W.* of safflower, dry it and reduce it to powder; then add 1 S. W. of impure carbonate of soda (*sajimati*), and rub them with the hands for about 12

* Here the expression S. W. is employed to indicate tolas (1 tola = ·41 oz. Ad.).

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BENGAL. Dinajpur.

minutes. Then put them on a cloth strainer, and allow 40 S. W. of water to drain through them. In this water steep the silk a whole dry, and wash it. Then put it into an infusion of tamarinds, which is prepared thus. Take 5 S. W. of ripe tamarinds freed from the shell, and having rubbed them well with 20 S. W. of water, strain this for use. In this infusion the silk is kept between 48 and 72 minutes and is then dried in the shade. The *kusum* colour is better fixed, but is not such a fine red; still, however, it is a beautiful colour. The only differences in the process are that 30 S. W. of safflower are used, and that ¼ S.W. of alum, and S.W. of lime-juice are added to the infusion of tamarinds. *Dinajpur in Martin's Eastern India*, II., p. 965.

Kusum as a dye for cotton. The third colour called *kusum* is not well fixed; but is a bright beautiful light red, like the pomegranate flower. For 20 S.W. of cotton thread take 1½ ser of dry safflower, powder it on a cloth, and wash it, until the yellow colour is entirely separated. Then add by degrees 15 S. W. of impure carbonate of soda (*sajimati*) and rub them together for an hour, until they become scarlet. Then put them on the strainer, and filter water slowly through them, until all the colour is carried away, and keep this infusion of safflower. At the same time put 60 S.W. of tamarinds freed from the pod, into 2 sers of water, rub them and strain the infusion. Mix the infusions, and divide them into two equal parts. Put the thread into one part for an hour, then wring it, and put it in the remaining half of the infusions for three hours. Then wash, and dry in the shade. *Martin's Eastern India*, II., 969-970.

Purneah.

In this district (Puraniya-Purneah) safflower (*Kusum*) is an object of some little more importance than towards the east. It is never sown by itself, so that no estimate can well be formed of the expense attending its cultivation. The collecting the flowers does no injury to the seed, as they are pulled off while naturally separating from the young fruit. The oil is always extracted by the former, and the seed does not therefore come to market, so that in the tables, I have calculated the produce by the value of the oil. The seed is put into an earthen pot, which has a hole in the bottom, and is placed over another that is sunk in the ground. A cover is then put over the mouth of the pot containing the seed, and a fire is kindled over and around it. As this burns, the oil falls into the pot below. It is therefore an empyreumatic oil, and is fit only for the lamp of the poor. The seed here is never eaten. *Martin's Eastern India*, III., 257—258.

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The **Carthamus** or *kusum* is a very common green, and is sown in fields to a considerable extent. It gives the flowers as a dye, the

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leaves as a pot-herb, and the seed for oil, without its growth being in any manner affected, so that it is a valuable plant. *Puraniya-Purneah in Martin's Eastern India*, III., p. 237.

UNITED PROVINCES.

In the United Provinces as well as in Bengal (see p. 151), safflower is much used for dyeing wedding apparel. The *kusum* dye has been nearly driven out of the market by aniline dyes. The flower as prepared by cultivators for the dye market is sold in Cawnpur at R15 to R30 per maund (82·3 lbs.). The colouring matter dissolves in alkaline water and can be easily extracted from the flower. The *kusum* colour gradually fades away and does not last long.

CENTRAL PROVINCES.

Safflower dyeing in the Central Provinces is described thus. The flowers are first pounded with a pestle in a wooden mortar. The pulpy mass resulting is then squeezed by hand into small round balls, dried, and is then sold to the dyers. The dyers again pound these balls, and after steeping them in a little water, knead them under their feet for several hours. The mixture is then placed in an outstretched cloth and cold water poured on it until the water running off loses its yellow tinge. The pulp remaining is then mixed with the ashes of burnt plants, generally those of the *jagin* and *sajji*, the mixture resulting is similarly placed on a cloth and water poured on it. The red liquid which after a time flows off from the mixture is the safflower dye. It is collected in three separate vessels, the liquid contained in the first of which possesses the deepest tinge, and is the most valuable.

PANJAB.

Karnal.

In the Karnal district of the Panjáb *karar or* safflower is usually sown very sparsely with gram or on the edges of the fields, seldom by itself. Only small quantities are sown. The soil requires little preparation and no further care. When the flowers open, the women pick out the petals; three days later they repeat the operation; and again a third time after the same interval. If hired they take a quarter of the picking as their wages. The petals are bruised the same day in a mortar, rolled between the hands, and pressed slightly into a cake. Next day they are rolled again, and then spread in the sun for two days to dry, or still better, one day in the sun and two days in the shade. One seer of petals will give a quarter of a seer of dry dye. Any delay in the preparation injures the dye.

The dry dye is called *kasumbh*, and is the yellowish red colour with which the clothes of the village women are ordinarily dyed. The dyer (*nilgar*) has the cloth and dye brought to him, retains one-fifth of the dye as a perquisite, and is also paid for his trouble. A bitter oil is expressed from the seeds which is used for burning only. Forty seers of seeds will give 3½ seers of oil. (*Gazetteer of the Karnal District*, 1890, p. 208.)

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Simla Hill States.

It is reported from the Simla Hill States that the dye is prepared by steeping the petals in cold water. The petals are sold at the rate of 2 seers per rupee.

Hoshiarpur.

The particulars which follow were furnished by the Deputy Commissioner, Hoshiarpur. Each day's pickings are beaten in a mortar with a wooden pestle, water having been previously sprinkled over them. The florets are then kept in the shade in a basket covered with cloth. At night they are again beaten and rubbed between the hands. The next day the mass is exposed to the sun to dry. When dry it is ready for the market, and in this state is bought by dyers. The mass or pulp is now again beaten, reduced to powder, and strained through a sieve. The powder is now placed in a cloth having the four corners secured, a stream of water is then poured on it until the water passes out quite clear, but no beating takes place. This process eliminates the extra yellow colour which the florets contain in addition to their valuable red dye. Powdered Sodium Carbonate *sajji*, is now added in the proportion of $\frac{1}{16}:1$; at first a deep red colour is precipitated. This and the subsequent lighter liquid are collected in separate vessels. At the same time an acid solution is prepared either by steeping unripe mangoes or *imli* (**Tamarindus indica**), or *rishtas* (dried apricots) or "galgal" (**Cochlospermum Gossypium**) in water for some hours. The article to be dyed is washed in clear water and wrung out. It is then steeped in the lighter solution to which acidulated water has been added. The fabric is next steeped in the liquid which is to impart the final tint. The article is finally washed twice or thrice in acid water and then dried. Local safflower is not made into cakes. It affords several shades of colour, but they are all evanescent. A method of fixing the tints does not appear to be known. The dye-powder sold in the bazar is often found adulterated with "masor" flour and red brick powder.

Ambála.

In the Ambála district the flowers are pounded in a wooden mortar, they are then thrown into a coarse cloth which is fixed on to a four legged wooden frame. The weight of the pounded flowers brings the cloth down to within a short distance from the ground. Water is then poured over the cloth. On passing through the water is at first yellow. When the exudation becomes of a red colour the flow of water is stopped. The substance left is considered pure safflower, and to it is then added an ounce of crude carbonate of soda, *sajji*, to every pound. The whole is well mixed, water is again poured into the cloth, and this time a vessel is placed under the frame to receive the exudation. The substance left in the straining cloth is of a brown colour and is considered refuse. To every 2lb of the dye material so extracted 8 ounces of lemon-juice or dry mangoes is added. The whole is allowed to stand in an earthen jar until the dye settles at the bottom of

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the vessel. The sediment thus obtained is pure dye and is of a greenish colour. It is finally dried and kept in earthen jars ready for use. PUNJAB.

SIND.

In Sind the flowers are pounded as described above (Ambála) and made into balls which are dried in the shade. When quite dry these balls are broken up and passed through a sieve, when the powder is ready for dyeing purposes.

BOMBA

Safflower dye cakes are sold in Gujarát at 2 to 2½ lbs. per rupee. The cakes are made from the pulp from which the comparatively valueless temporary yellow has been washed. These cakes contain carthamin as well as the more permanent of two yellows, and form the basis required to produce the various tints of yellow, orange, pink and red so common in native-dyed cloth.

As a dye Chinese safflower is considered superior to Indian and Bengal dye to that of Bombay, which is thought very poor (Mr. J. Mollison).

BARODA. Nar village. Petlad taluka.

In Baroda (Nar village, Petlad taluka) the dye is only extracted for dyeing pagaries and the colour is prepared thus :—The well pounded flowers are kneaded with water and tied up in a cloth; the cloth is then fixed to a tripod and water is poured over the moist mass to extract the soluble yellow colour. After a thorough washing the flowers are squeezed to remove the last traces of yellow. They are then removed from the cloth, spread out and sprinkled with crude potash in the proportion of 1 oz. of the salt to 3 pounds of the petals. The flower pulp is again transferred to the cloth and water is poured on it to remove the red colouring matter. To the red liquid thus obtained half a pound of the acid juice of limes or of unripe mangoes is added for each pound of safflower and just before dyeing the cloth a second-half pound is added.

BURMA. Kyauksé District.

It is reported from Kyauksé, Burma, that the practice of extracting a dye from the flowers has now entirely ceased.

Medicine.

BENGAL. Dumraon.

In Bengal (Dumraon) the oil is considered by the ryots as a valuable remedy for itch. A cure is said to be effected after 3 to 6 applications. The young green plant is said to be very efficacious in colds. It is believed to keep the system warm. The charred oil is used for healing sores and for rheumatism. As a veterinary medicine the oil occasionally finds use in healing sores on cattle.

UNITED PROVINCES.

The oil of the seed is used as medicine in the United Provinces. The meal of the cooked seed is called *harira* and is considered a curative and specific for colic pain.

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CARTHAMUS tinctorius. A digest of the correspondence conducted by the office of the

CENTRAL PROVINCES. In the Central Provinces the oil extracted by the dry hot method is employed as a salve for sores on cattle.

SIND. The seed is employed as a cooling medicine (*thadhol*); it is sometimes boiled and made into gruel. The oil is considered a mild purgative.

Food.

BENGAL. *Conf. p. 168.* The young plant when still green is much used in Bengal as a pot herb. The white substance in the seed ground and boiled in water is said to be largely eaten by the poorer classes as a substitute for thick milk, notwithstanding that it generally brings on indigestion. The oil is much used for cooking. It is largely employed by the less well-to-do in marriage ceremonies for preparing *puris* (cakes) fried with *kusum* oil or clarified butter.

UNITED PROVINCES. In the United Provinces the tender leaves are cooked and eaten as a vegetable. The seed when parched is eaten along with parched gram or with dried *mahwa* flowers. The two dried separately and then pounded together are made into balls (*laddoos*) and eaten by the poorer class.

CENTRAL PROVINCES. The oil expressed by the dry cold method is reported to be used in the Central Provinces for culinary purposes, as well as for lamps.

PANJAB. Simla Hill States. The poorer classes in Mahlog, Simla Hill States, mix safflower oil with *ghí* and use it in the manufacture of sweetmeats.

Hoshiarpur. From Hoshiarpur it is reported that pure *kasumba* oil is used to adulterate *ghí* for the preparation of sweetmeats in large trade centres, such as Amritsar and Lahore. The oil cannot be used alone for culinary purposes; it is employed to adulterate *ghí*, having no smell. In the Western districts of the Panjáb, bruised *kasumba* seed is eaten.

BOMBAY. In Bengal safflower, sesamum and groundnut seeds are often ground together and furnish the sweet oil of the bazars. Pure safflower oil is extensively used in adulterating *ghí* and sesamum oil. It is worth in the Deccan 8 lbs. per rupee.

BURMA. *Conf. p. 159.* The tender leaves are used as a vegetable in most of the districts of Burma under the name of *hsu-wine-ywet*. The leaves are boiled and eaten as a sort of spinach. They are also used in curries.

Fodder.

BENGAL. Dumraon. In Bengal (Dumraon) the oil cake resulting from the cold dry process is fed to cattle and is said to be fattening.

Cattle must be accustomed to the cake before they eat it with relish. It has this advantage over other edible oil cakes, that it keeps free of mould and good for a long time and, moreover, is usually cheaper.

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A report from the United Provinces states that the whole plant before flowering is cut and given to cattle. UNITED PROVINCES.

The following particulars relate to the Hoshiarpur district, Panjáb. By mixing the seed with rape seed and then expressing the oil, the oil cake becomes useful as fodder. Pure **Carthamus** oil cake is not employed for the purpose—if given to milch cattle it is said to dry up their milk. PANJAB. Hoshiarpur.

In Bombay it is said that the cake from husked seed contains an appreciable percentage of husk. The latter is coarse and fibrous. An undue proportion of husk makes the cake more or less unsuitable for cattle food. If safflower cake is good, *i.e.,* if it contains a small percentage of husk, it is recognised in the Deccan as one of the very best and cheapest of foods for milch cattle. Cattle have to get accustomed to safflower cake before they eat it greedily. It has an advantage over the edible oil cakes in that it keeps free of mould and good for months, and can therefore be bought in seasons when it is cheap and then stored. In outstations in the Bombay Presidency, good cake can be had when cheap at the rate of 80 lbs. per rupee; it ordinarily costs one rupee for 60 lbs. in Poona. BOMBAY.

Fuel.

In Bengal the dry stalks are commonly used as fuel. The cold dry pressed oil is employed for lighting purposes. BENGAL.

The dry stem easily takes fire and is used in the United Provinces for making matches. It is cut into small pieces of equal length, these are dipped at one end in liquified sulphur, and kept ready for use. The wood of the plant is so combustible that if two dry stems be rubbed together fire is produced. UNITED PROVINCES.

Insecticide.

In Bengal the dried plants are stated to be kept by the people in their houses to destroy bugs. SIND.

Domestic and Sacred.

The colour is considered by the Hindus of Bengal as particularly auspicious and sacred. It is perpetually in request at religious ceremonies. The orthodox Hindu (in Behar) will not allow his son or daughter to wear any apparel at the wedding ceremony which is dyed with European dyestuffs. It is believed the priest would lose half the respect of his people if he did not exercise sufficient discretion in choosing the dye for his *chudder* (sheet) or *mureth* (head dress). Hence it will be seen that religious rather than economic considerations have saved the safflower industry from complete extinction. BENGAL.

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CARTHAMUS tinctorius. A digest of the correspondence conducted by the office of the

Trade.

TRADE.

Statement showing Exports of Safflower Dye, 1874-75 to 1902-03.

Year.	Quantity. Cwt.	Value. R
1878-79	4,977	1,86,711
1884-85	2,167	83,083
1890-91	3,562	49,477
1894-95	1,790	37,118
1898-99	2,605	33,203
1902-03	2,969	56,606
1903-04	4,313	67,506

Of the amount exported in the year 1903-04, the province of Bengal furnished 4,273 cwt., vlue R66,786; the small balance 40 cwt., value R720 was contributed by Bombay. The receiving countries were as under:—

	Cwt.	R
United Kingdom	164	7,358
China-Hongkong	2,812	37,341
Japan	261	4,745
Straits Settlements	1,076	18,062
TOTAL	4,313	67,506

SEED SPECIMENS

Safflower seeds registered in the Indian Museum, Industrial Section.

Registration No.	Name.	Whence received.	REMARKS.
6525	Carthamus tinctorius	Sind	Medium size seed, slightly ridged.
6626	Ditto	Bombay	Seed of the dye plant.
6627	Ditto	Do.	Seed of the oil plant.
6784	Ditto Thornless variety.	Cawnpur	Medium size seed, dull white colour with usual marking.
6946	Carthamus tinctorius Thorny variety.	Do.	Smallish seeds, dingy white, with raised markings characteristic of safflower.
7623	Ditto	Nagpur	Rather dingy white seed of varying size, slightly ridged.
8318	Ditto	Bengal	Strongly ridged seeds.
11851	Ditto	Hyderabad, Deccan.	A bold seed, with the raised markings well defined.
14497-1	Ditto	Amraoti	A bold clean white seed with usual markings.
18168	Ditto	Gujerat	White seeds, slightly ridged.

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Safflower oil registered in the Indian Museum, Industrial Section.

OIL SPECIMENS.

Registration No.	Name.	Whence received.	Remarks.
6296	Carthamus tinctorius Cultivated form.	Hoshiarpur .	Colour, bright yellow.
6457	Carthamus tinctorius	Umballa .	Orange colour.
6526	Ditto . Prepared by cold dry expression.	Sind . .	Yellow.
6624	Carthamus tinctorius. Oil from dye plant.	Bombay .	Clear light orange.
6625	Carthamus tinctorius. Oil from oil plant.	Do. .	Clear deep orange.
6682	Carthamus tinctorius	Madras . .	Rather deep yellow.
6785	Ditto . Thornless variety.	Cawnpur .	Light orange,
6787	Ditto . Thorny variety.	Do. .	Clear light orange.
8319	Carthamus tinctorius	Bengal . .	Colour, yellow.
14497	Ditto	Amraoti .	Clear light orange.
14498	Carthamus tinctorius Oil, mixed with sesamum and arachis oil.	Do. .	Slightly darker than the preceding.
15171	Carthamus tinctorius	Calcutta .	Colour, deep orange.

Safflower dye registered in the Indian Museum, Industrial Section.

DYE SPECIMENS.

Registration No.	Name.	Whence received.	Remarks.
5250	Carthamus tinctorius. Dried flowers.	Lucknow .	Inferior.
5783	Ditto .	Sylhet . .	In cakes fair.
6294	Carthamus tinctorius. Cultivated form.	Hoshiarpur .	Inferior.
6295	Carthamus tinctorius, as prepared for dye market.	Ditto .	Good.
6631	Ditto .	Bombay .	,,
7447	Carthamus tinctorius. Thornless variety.	N. W. P. .	,,
18168-1	Dittto .	Gujrát .	Bad.

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G. I. C. P. O.—No. 1385 R. & A.—26-8-1904.—2,500.—P. M. M.

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AGRICULTURAL LEDGER.

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BIXA ORELLANA.

THE ANNATTO-DYE PLANT.

[*Dictionary of Economic Products, Vol. I,* B. 523-38.]

ANNATTO DYE.

A Review of existing information. By I. H. BURKILL, *Officiating Reporter on Economic Products to the Government of India.*

Bixa Orellana, *Linn.; Fl. Br. Ind., I., 190; Ind. Kew., I., 309.*

THE ANNATTO OR ARNOTTO DYE.

Vern.—*Latkan, latkhan, watkana,* HIND., BENG.; *Kong knombi,* SANTAL; *Jarat, jalandhar,* ASS.; *Gúlbas,* URIYA; *Powasi,* CHITTAGONG; *Reipom, urei-rom,* MANIPUR; *Shál-ke-pandú-ká-jhár,* DUK.; *kisri, kesari, kesuri, sendri* or *shendri,* MAR.; *Jáphara-chettu, jafra-vittulu-chettu, kurungu-múnji-vittulu-chettu,* TEL.; *Japhra-maram, japhra-virai-maram, kurungu-munjit-varai-maram,* TAM.; *Kappa-mankala, rangamali, rangamali-hannu* (the fruit), KAN.; *Thitin,* BURM.

Habitat.—Annatto or Arnatto is a dye obtained from the coating of the seed of an American shrub or small tree known as **Bixa Orellana**. It is a plant easily cultivated, is not very exacting in the matter of soil, and has been taken to nearly every country of the Tropics. The flowers are showy, sometimes white, sometimes pink; and often it is grown as an ornamental plant in gardens. Swampy ground it does not like, and the least frost is prejudicial: otherwise the plant is ready to accommodate itself to most conditions found within the Tropics where the rainfall is 50-60 inches.

The plant grows to a height of 12-15 feet.

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Annatto.

HABITAT.

The leaves are heart-shaped, sharp at the end, and even at the sides rather like those of the common lilac of gardens in England. The flowers are borne at the ends of the branches in a loose bunch and are large, regular and showy. The pods are rather urn-shaped in general outline, laterally compressed and slightly beaked above; they are covered with weak prickles. At full maturity they crack open from the beak downwards, along the two edges and expose the seeds. The Annatto harvest begins when two or three of the pods of a bunch are gaping slightly: then is the time to cut off the whole and to take them to any suitable place for shelling out the seeds. These seeds are either dried carefully in the sun and sent into the market as they are, or else the dye is prepared from them by one of the processes to be described.

Cultivation.

CULTIVATION.

The cultivation of **Bixa** is very simple; and the bush has few enemies. The first return comes in the second year.

Seeds from which the dye may have been washed are sown at the beginning of the rains about 7-8 feet apart in prepared soil. Two or three seeds may be put into each hole and ultimately the weaker seedlings eliminated, or else the seedlings may be grown in a nursery and planted out at the distance named. On the fattest lands the intermediate plants may ultimately have to be removed, so that the bushes may stand 15 feet apart. As the young plants come up a little shade is given either by placing large leaves over them to protect them during the heat of the day, or by putting mats over them. When they are a foot high they may be considered to be established and need no further shade. Weeding is necessary until by their own growth they so cover the ground as to keep weeds down. Pruning is desirable to make the plant bushy; for the flowers are borne on the ends of the branches.

Annatto plants make good hedges and may be used for wind breaks for other kinds of cultivation.

YIELD.

The yield per acre is set down at $6\frac{1}{2}$ to $7\frac{1}{2}$ maunds of seeds and as 9-10 seers of seed will give one seer of the prepared dye, it is 26 to 30 seers of dye. The first full crop may be set down at 5 cwts. (4 mds.) of seed per acre; the subsequent crops increasing.

The parts of India with rainfall suited to its cultivation are Lower Bengal, Dacca, Mymensingh, almost all Assam, the hill regions over Orissa, the Burmese coast, and North Burma, the coast south of Bombay and the lower hills of Southern India.

Of Ceylon the greater part of the island is suited to its cultivation, and an extensive plantation under European supervision exists at Matale.

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Annatto. *(I. H. Burkill.)*

CULTIVATION.

Except for the coast south of Bombay, I have evidence that the plant already exists in all parts of India suited to it; but the pink-flowered form seems to be the better kind and it is not always the one already growing.

The Dye.

THE DYE.

The outermost coat of the seed is the part which contains the dye. The dye principle is a chemical body known as Bixin, isolated as glistening red crystals and examined by Zwick (*Chem. Zeitung Repert.* 24, page 66) in 1900 who ascribes to it the formula $C_{28} H_{34} O_5$. His results agree with and complete the earlier ones of Etti.

The percentage of Bixin present in the seed coat is not very large and may be considerably less in commercial annattos because of the admixture in them of parts of the seed—often the whole seed ground up—and of substances added in manufacture.

There are recorded, however, no recent analyses of the seed coat which might be quoted for the sake of obtaining a standard.

Uses.

When Columbus discovered America, Annatto dye was used by the fierce Caribs as war paint. They called it Roucou—a name still used by the French. It is now employed chiefly to colour butter and cheese, in pharmacy for colouring some ointments and to a less extent as a dye for silk, calico, wool, sheep-skins, feathers, wax, ivory, bone, etc., and in the paint industry. The commonest tints which it is used to give are yellows—such yellows are the primrose and cowslip yellows of butter and cheese, but it can also be made to give reds. The Caribs used to make their faces and bodies crimson with it.

The markets for it now are chiefly in Europe and North America, and the chief countries supplying it are Brazil, French Guiana or Cayenne, the French West Indies, and to a less extent the British West Indies. Ceylon and Madras also send a small quantity of seed to Europe.

KINDS IN THE MARKET.

The prepared dye enters the market in several forms, the chief of which are the following:—

(1) as rather hard, reddish, oily, homogeneous rolls or cakes smelling somewhat like urine:—origin French Guiana (Cayenne);

(2) similar rolls or cakes, but rather granular:—origin West Indies;

(3) brown rolls with a pleasant smell:—origin Brazil.

The annatto of Cayenne obtains the highest price; and in France it may, sold in bulk, touch at times, 200 francs per 100 kilos. The less valuable kinds sell at much lower prices down even to 30 francs per 100 kilos. An average price in Germany seems to be about 80 marks per 100 kilos.

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PRICES OF THE DYE.

The seeds have sold in Europe during the last years at $2\frac{3}{4}$ to 4 pence per lb.

These rates translated into Indian currency and calculated per seer are—

	R	a.	p.
For best Cayenne annatto in France per seer .	1	3	0
" inferior annatto " " .	0	3	0
" average annatto in Germany " .	0	9	6
" seeds in London . . . . . 0 5 6 to	0	8	0

These prices bear out the remark made by **Dr. H. A. Alford Nicholls** in his excellent *Text-book of Tropical Agriculture* (London, 1892), page 248 : "The purer the dye is sent to the markets, the higher will be the prices obtained for it; and unless a fine article be prepared *it is better* to ship the dried seeds, from which the dye is extracted in England and the United States."

PREPARATION OF GOOD ANNATTO.

The preparation of annatto in any form is quite a simple one. The better stuff is made in the following way :—

The seeds, taken out of the capsules, are placed in a receptacle; and hot water is poured over them until they are well covered : they are then stirred for a considerable time until the colouring matter has been washed off. That done, the liquor and seeds are separated by straining through any suitable material. The former carries with it all that is of value, and is set to stand so that the dye may fall to the bottom ; the latter are thrown away. When all the dye has settled, the supernatant water is poured off as far as possible, and the fine residue placed in the shade where the rest of the water may evaporate without the aid of artificial heat. As soon as the mass is dry enough to be kneaded, it is moulded by hand into rolls or cakes and these are put by until they are perfectly hard. When moulded they are wrapped in clean leaves, plantain or banana, and when dry they are packed in layers in boxes.

Brazil sends into the European market annatto in the form of rolls, but the dye is not always prepared with requisite care. The rolls weigh 50—100 grammes (4·3—8·6 tolas), and are brownish on the outside and a reddish green inside. The market knows the shape under the names of flag and roll annatto. The cakes are chiefly made in Cayenne and are called cake annatto.

The preparation proceeds for cake annatto as for roll annatto until the point is reached at which the roll annatto is moulded by hand ; when instead it is cut into squares with a knife and left wrapped in clean leaves to get its last drying.

IMPROVEMENTS.

An improvement upon this process is given by **Semler** in his *Tropische Agricultur, II* (Berlin, 1900), p. 636. He says : Pour hot water over the seeds and stir as usual : then let the mass soak for

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Annatto. (*I. H. Burkill.*)

BIXA Orellana.

some days; filter off the seeds, let stand for a whole week, and afterwards pour off the supernatant water and dry.

PREPARATION OF THE DYE. *a.* standing. *b* no heat. *c.* precipitation chemically.

Another suggested improvement is to use cold water and no heat in drying.

A third improvement is, use a 2 per cent. solution of soda instead of pure water for pouring on to the seeds, and to throw down the dye afterwards by adding dilute hydrochloric or sulphuric acid.

This last suggestion from a chemical standpoint is a sound one, and would seem to be in use among the manufacturers who in Europe prepare annatto from the imported seeds.

PREPARATION OF INFERIOR ANNATTO.

The preparation of an inferior annatto is thus done in Guadeloupe and the French West Indian islands.

The dry seeds are crushed between rollers; and the fine powder resulting, which consists in chief part of seeds and in small part of the useful seed coat, is thrown into water and allowed to settle after which the surface water is run off: the sediment is then boiled, with the lower water only, for four or five hours. After the boiling as much water as possible is squeezed out by means of boards and the remaining paste is packed into casks in layers with plantain leaves between them. This paste must be kept moist, or it will deteriorate.

As of course the stuff so prepared contains a large percentage of useless matter it fetches the low prices recorded above.

ANNATTO AS A PIGMENT.

Annatto for the paint industry.—A specially high-priced annatto is thus prepared: the Indians of Guiana dip their hands in oil and with them wet rub the fresh annatto seeds and get a sticky mass which has to be scraped off. This mass is dried like the ordinary preparation and like it comes into the market wrapped in plantain leaves. There is but a very small demand for such material and its only use in Europe is in the paint industry. It comes into the market in little irregular shining red lumps. Gum and other substances of plant-origin may have been mixed in it as the natives like it so in order to smear their bodies with it, not by way of ornament but, so it is said, to keep away mosquitoes.

ANNATTO IN BUTTER AND CHEESE.

There is a supposition that a little annatto added to butter and cheese has a preservative effect, but this is very doubtful. The adding of it is rather merely to give it a colour which somehow in the English mind is associated with butter. The amount added is very small, for ·03—·08 per cent. of a good preparation of annatto is all that is required to give the desired tint. Moreover, the annatto gives no taste and no smell to the butter. Nevertheless, it is said that annatto is in the Spanish Americas added to cocoa not to give it a colour but to give it a certain flavour. This fact as Semler remarks stands unreconciled to the statement that in putting annatto in butter we are doing nothing to alter the flavour.

THE DYE.

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BIXA Orellana.

Annatto.

CHEMISTRY OF COMMERCIAL ANNATTO.

Nearly twenty years ago Lawson reported in the *Pharmaceutical Journal and Transactions* (1885-86, page 645) upon ten samples of annatto which he had obtained in England—two Nos. 4 and 7 direct from manufacturers and the rest from dealers. Since his report no particular attention has been directed to the commercial product, and therefore we cannot cite more recent analyses.

He had five samples of red rolls which on analysis did not differ very much. The description reads as if they were flag annatto from Cayenne or the French West Indies.

The figures which he gives are as follows :—

	No. 1.	No. 2.	No. 3.	No. 6.	No. 5.
Moisture	21·75	21·60	20·39	18·28	18·00
Colouring matter	3·00	2·90	1·00	1·80	3·00
Extractive	57·29	59·33	65·00	65·67	58·40
Soluble ash, mostly common salt	13·20	12·57	7·50	11·75	10·0
Insoluble ash	4·76	3·60	6·11	2·05	10·6

No. 6 was dirty, full of hairs and foreign matter, and No. 5 gave out a disagreeable odour on ignition.

Lawson remarks the high percentage of soluble ash present. In most cases it consisted of common salt which he thinks was added as a preservative and because the presence of salt heightens the colour.

He had three samples of cake annatto bought from dealers, and one, No. 7, obtained from a manufacturer. His analyses gave the following result :—

	No. 7.	No. 9.	No. 10.	No. 8.
Moisture	15·71	19·33	22·50	38·18
Colouring resin	5·40	5·90	9·20	12·00
Extractive	26·89	23·77	28·50	20·82
Soluble ash	18·50	15·00	13·80	20·00
Insoluble ash	33·50	36·00	26·00	9·00

The figures are very unlike those for roll annatto in containing more colouring matter, less extractive and a large quantity of insoluble ash chiefly potassium carbonate.

Mr. Lawson also obtained a paste from a manufacturer and analysed it with the following result :—

	No. 4.
Moisture	69·73
Colouring resin	8·80
Extractive	19·47
Soluble ash almost all NaCl	2·00
Insoluble ash	...

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Annatto. (I. H. Burkill.)

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CHEMISTRY OF COMMERCIAL ANNATTO.

This paste he got put to a practical test and ½ oz. coloured 60 lb. of butter satisfactorily. It was the only really satisfactory preparation among the ten which he examined. As it was very moist it is necessary in order to compare it with the others to recalculate the figures to what they would be were some 20 per cent. of water only present, whereas nearly 70 per cent. was present. Remove 50 per cent. of water from No. 4 and we get 17·60 resin, 38·94 extractive, and 4·00 ash. No single sample in the whole series comes up to this in percentage of resin. All the rolls are far inferior; they have had added to them a good deal of salt, in itself not injurious. The first three of the cakes, Nos. 7, 9 and 10, have had added to them a lot of chalky matter. Remove the ash from them and the other figures recalculated would not be unlike those of the best sample (Lawson's No. 4).

Thorpe, *Dictionary of Applied Chemistry*, vol. 1, 1898, p. 174, quotes an analysis by Winter Blyth of a good annatto, wherein 28·8 per cent. of resin was found, 22·5 per cent. of ash, 24·5 per cent. of extractive matter, and 24 per cent. of water.

The conclusions are that all the red rolls contained far less colouring matter than they might and had had common salt added to them; that the cakes had got chalk or some very similar unnecessary substance in them, and that few of the preparations marketed, at least at the date at which Lawson wrote, were really good.

More recent writers, *e.g.*, Chevallier and Baudrimont, in their *Dictionnaire des Alterations et Falsifications des Substances Alimentaires, Medicamenteuses et Commerciales*, Paris, 1897, II, p. 239, speak of the extent of adulteration but without giving recent figures which I can quote. They give directions for the testing of commercial samples by estimating the ash first and then testing the tinctorial properties by the side of a standard sample.

Lawson alleges his belief that a great deal of adulteration by turmeric was going on, but he does not prove it.

Production of Annatto in India.

ANNATTO IN INDIA. Two varieties.

All that can be said about the introduction of annatto into India will be found in the pages of the Dictionary of Economic Products. There are two forms of the plant in this country, the one with pink flowers and red pods, the other with white flowers and green pods. In 1895 Sir George Watt instituted an enquiry as to where these two forms occur in India and how. The results of this enquiry are now to be given. Wild, the white flowered plant may be found in the districts of Murshidabad, Midnapur (Ghatal), and Raniganj, in Bengal. It also occurs about Calcutta and some places in the 24-Perganas. The colour of the flowers of the plant grown in Dacca, Chittagong

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ANNATTO IN INDIA.

and Jalpaiguri is not known to me. It was cultivated in the northern division of Dacca as a mercantile speculation before 1840 but without success. The white-flowered **Bixa** is further found in Cachar, Goalpara, Jorhat and Nowgong of Assam. The pink-flowered plant is said to be wild in Lakhimpur, Assam. The same form is cultivated in Jorhat as an ornamental shrub. In the Central Provinces in the districts of Sambalpur, Raipur, Nagpur, Chhindwara, **Bixa** is found cultivated, chiefly the pink-flowered form; and in the Chhindwara district it has run wild to a small extent. It will be noticed now that these districts border on the districts of Bengal whence the plant is reported wild. The cause of its occurrence thus would seem to be that the dyers of Murshidabad took it up as a dyeing stuff, and by encouraging its growth in this way, it being cultivated in gardens chiefly, led to its dissemination through the region from which they were wont to draw their supplies of Kamela (**Mallotus philippinensis**), the dye for which it was in some measure substituted. Nothing is more natural than that the hill people of the Uriya tracts who formerly supplied very much more Kamela to the dyers of Murshidabad than they have done for the last few decades, should take up the cultivation of the newer product demanded in its place. It is also found in Betul, I believe only in cultivation. Both white and pink-flowered bushes are to be found half wild on the hills of Vizagapatam, but chiefly the pink.

Kamela *vs.* Annatto.

Formerly, if not still, the plant could be seen in Bombay gardens.

In Burma the cultivation of pink-flowered annatto was formerly of some extent, but now is very little; for the dye has been superseded by aniline dyes there also. The plant may be found about towns and villages, alike in the dry districts of Mandalay, Kyauksé, Sagaing, Pakokku, etc., where middle aged men remember the collecting and use of the seeds as occurring when they were children, and in the damper districts of Tenasserim, where the seeds are still a very little used and about Bhamo. Kurz remarks that it had in his time (1875) run wild in the Pegu Yomah. It is also, it seems, not an uncommon plant in Manipur.

The pink-flowered form is to be found in the Northern Shan States, *e.g.*, at Hsipaw, and it is to be found on the Siam border, *e.g.*, at Myawadi. In neither place is the dye now used.

In Southern India both the pink and the white-flowered bush is grown in the planting districts of Mysore and in Travancore, and the former has been cultivated on a commercial scale. In Ceylon it is commercially cultivated. The neighbourhood of Bangalore of recent years produced most of the seed shipped to England from Madras. Now the trade is moribund as the following report from Mr. J. Cameron

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DYEING METHOD.

of that place shows: "The Annatto plant, of which there are two local forms, has long been cultivated on a small scale about Bangalore and in some parts of the adjoining district of Kolár. But subsequent to the introduction of cheap European dyes, some years ago, the cultivation became very limited. Local plants are not in flower at present. But the enclosed drawings represented the leaves, fruit and seed in the two varieties. No. 2 (white-flowered) is cultivated more for ornament than use as the seeds are few in number and much inferior in quality to those of No. 1 (pink-flowered). The seed of the latter was formerly much valued by dyers, and is still sold in the Bangalore bazár at the rate of six seers to the rupee. I have been unable to ascertain the actual quantity produced in the local market though it is said to be very trifling compared to what it was some 25 to 30 years ago. At that time the plant (No. 1) was cultivated in villages around Bangalore. But most of the original bushes have disappeared and only a few are now found in native gardens. I think it is therefore very improbable that the so-called Madras Annatto comes from this locality. The measuring seer to which I have referred above is equal to 80 tolas, so that about 480 tolas of seed is sold for a rupee—not by any means a remunerative industry!" (*Letter No. 262, dated 20th January 1904, to R. E. P.*)

Mr. A. G. Castlestuart Stuart informs me that the shrub does not occur in the north-western part of the state of Mysore, that there is very little in cultivation in the Shimoga district (apparently pink-flowered) near the villages of Muppani and Bellene, and that it is rare in the districts of Kolar, Chitaldrug, Tumkur and Mysore.

Vizagapatam sends a little seeds to Madras and to Vizianagram.

Murshidabad.

It will be best to describe, first the method of dyeing as practised in the chief centre. This centre, as already said, is Murshidabad. Roll and cake annatto are unknown. The seeds are bought in the bazar at about one rupee per seer. Two seers of water are put into a copper basin and placed on the fire to boil. When the water commences to steam half a seer of fuller's earth, *sajimati*, is thrown into it and then one-third seer of annatto seeds. After a little time has been given for the colour to be taken out of the pulp on the seeds, there is thrown into the vessel the silk thread to be dyed—one seer. Shortly the water comes to a boil and then stirring is necessary in order to prevent the silk from resting on the hot bottom of the pot. The length of time required is judged by the tint that the silk has taken. When the required colour has been got, the silk is withdrawn and put into cold water, washed, taken out, squeezed and dried in the sun. Magenta is sometimes used in combination with the annatto (Mr. E. V. Levinge, in letter, dated 23rd May 1896).

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Annatto.

DYEING. Ghatal.

In the sub-division of Ghatal the same process is used. Alum is sometimes used as a mordant.

Cachar.

In Cachar the process is essentially the same, but the mordants are different. Lemon-juice, ash-water, and tamarinds or the fruit of **Garcinia pedunculata** are used. It is agreed that the dye is rather fleeting. It is cotton cloths which are here dyed.

Jorhat.

In Jorhat the process in common use is as follows. The seeds are first boiled in a vessel in which plantain ashes have been mixed with water. As soon as the mixture reaches boiling point, the cloth to be dyed is immersed in it, and allowed to boil for about a minute. The vessel with the cloth still in it, is then taken off the fire, and the contents allowed to cool. The cloth is lastly taken out and dried; and a yellow dye results. The colour, however, is fleeting, and its tint varies according to the mordant used. The leaves of the *bhomrati* (**Symplocos grandiflora** or **S. spicata**) are also used as a mordant to produce a yellow dye with or without another mordant (**W. A. M. Duncan,** *Monograph on Dyes and Dyeing in Assam*, page 14).

Ash-water is prepared in Assam in the following way:—The trunk of a plantain tree or its root is split into pieces, dried in the sun, and then burnt to ashes. The ash thus produced is put by for future use. When required a quantity of ash is put into a thick basket and pressed down by the hand until fairly firm; then water is poured gently over it and allowed to percolate very gradually into a vessel placed underneath. The liquor is called *kharoni*.

Nowgong. Raipur. Sambalpur.

In the Nowgong district the seeds are pounded before water is poured on to them. Also in the Raipur and Sambalpur districts of the Central Provinces the seed is pounded in a mortar before use. The same mordants are there used as have been mentioned, with the addition of curds. In the Sambalpur district the seeds may be wrapped in a piece of cloth, which is pressed and squeezed by the hand under water until all the colouring matter has gone into the water when cloth and seeds are withdrawn together. Cloth, not silk, is the material dyed in these parts. Alum may be used in conjunction with it to get a pink colour. The Sambalpur method is reported as used also in Manipur.

Manipur.

Burma.

In Burma the process of dyeing, now all but extinct, is as described. Both silk and cotton were dyed, but now practically all of the little dyeing still done in the country by Burmans and Talaings is done with imported dyes.

United Provinces.

In the United Provinces and in the Raipur district of the Central Provinces, butter and curds are dyed with annatto.

In Bangalore seeds from pink-flowered plants were, says **Mr. J. Cameron**, sold at six seers to the rupee.

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Annatto. (*I. H. Burkill.*)

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DYEING METHODS.

PRICE OF ANNATTO SEEDS.

The cost of seeds in the Sambalpur district is about R0-6-6 per seer. The cost of prepared seeds is about R1 per seer in Murshidabad and Raniganj. They are quoted at twelve annas to one rupee per seer in Ghatal, Midnapur district, and at R1-8 per seer in Cawnpur.

I wish particularly to point out that at these rates annatto seed is sold in London cheaper than in the districts of India.

The future of Annatto as a dyestuff.

Cannot our Indian dyers be provided with cheaper annatto? It looks possible, and experimental growing is to be recommended. If instead of the desultory planting of a bush or two in garden hedgerows a small plot were only systematically cropped we should soon know how far the growing of annatto could be made profitable in India. Annatto, we are told, is giving place to aniline dyes because the dyers get the same effect at less cost with the latter, but then we notice that the supply of annatto seems to come to them at a too high price.

As an article of export.

The possibility of exporting annatto stands on a different footing, for the home demand is a very limited one. Any great influx of stuff would cause a glut in the market.

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G. I. C. P. O.—No. 1373 R. E. P.—23-8-1904.—2,500.—P. M. M.

THE

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1904—No. 13.

COIX SPP.

(JOB'S TEARS.)

[*Dictionary of Economic Products, Vol. II.*, C. 1683-1700.]

COIX SPP. OR JOB'S TEARS:

A review of all available information.

BY

SIR GEORGE WATT, M.B., LL.D., C.I.E., etc.

INTRODUCTORY REMARKS.

In December 1887, with the approval of the Government of India, I issued a circular letter regarding **Coix**, in which certain questions were pointedly put to my correspondents. This was followed by two most valuable papers in the *Kew Bulletin* setting forth the extent of European knowledge in the grain. In 1895 the information then to hand seemed to justify an even more thorough Indian inquiry than had been made and accordingly a *Circular Note* (*No. 13 of 1895-96*) was issued to all provincial Directors of Agriculture and sufficient copies sent to each to allow of distribution to all officials resident in localities where the plant was either known to exist or thought likely to exist. In due course this resulted in many reports coming to hand, accompanied by both botanical specimens and large samples of the corresponding grains. These have already been partially discussed in the Programmes of collections for the Indian Museum, Calcutta, and the Imperial Institute, London, for 1897-98 and for 1901. We are now, however, in a position to offer some definite information regarding the Cultivated and Wild forms of **Coix** met with in India. The remarks that follow may therefore be accepted as a review of the new information, along with a full statement of all past knowledge compiled from the better known authors of the world. What remains to be

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COIX Spp.	Coix spp. or Job's Tears.

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ascertained in the future may be said to be the actual area under the crop, the chemical properties of the various kinds of the grain now brought to light and the directions of possible future development.

From European Sources.

History.—So much attention was given by the early botanical writers to the subject of Coix that the inference might be drawn that it had formerly been a plant more extensively cultivated than at the present day. It is generally believed to be the *Lithospermon* of Pliny (*Book 27, Chap. 11*). During a period of some 300 years from the beginning of the 16th century onwards it was customary for European scientific authors to produce great works on the Natural History of the world, or of some particular country. In most of these *Lithospermon* or Coix is spoken of as a wild plant, or one cultivated as a curiosity only. The circumstance mentioned by some of the more directly botanical authors, such as Rumphius and Loureiro, that it was regularly cultivated in Eastern countries as an article of food seems to have escaped consideration. As representative of the opinions advanced by the historians, a passage may be here given from Holland's English translation of Pliny—a translation made in 1601 and thus about the very period in which Coix attracted so much attention. "But of all hearbs that be, there is none more wonderful than Greimile: some call it in Greek Lithospermon, others Ægonychon, some Diospyron and others Heracleos." "It bringeth forth close joining to the leaves, certain little beards one by one, and in the top of them little stones white and round in manner of pearls, as big as a cich pease, but as hard as very stones. Toward that side where they hang to their steles or tails, they have certain holes or concavities containing seed within." "And verily of all the plants that ever I saw, I never wondered at any more: so slightly it groweth, as if some artificial goldsmith had set, in an alternative course and order, these pretie beads like Orient pearls among the leaves." In accordance with the theory of signets it was very generally held (as affirmed in Pliny), that "a man no sooner seeth this hearbe, but he may presently know the virtues thereof and for what it serveth in Physike: a thing that he shall not observe again in any other whatsoever: for at the very first sight of those little stones, his eye will tell him what it is good for, without information from any person at all."

A.D. 70, circa.

Rumphius 1627–1702 Loureiro 1715–1796.

A. D. 1597.

Gerarde (*Herball, Ed. Norton, 1597, pp. 81-82*) gives a similar passage and one which also leaves little room for doubt regarding the identity of the plant. "It hath many knottie stalks producing from a tuft of threddy roots two foot high with great broad leaves like unto those of a Reede, amongst which leaves come forth many small branches like a strawe of corn: on the end whereof doth grow a graie shining seed or graine hard to break and like in shape to the

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seeds of Gromell but greater and of the same colour whereof I hold it a kind : every of which grains is bored through the middle like a bead and out of the hole cometh a small idle or barren chaffie eare like unto that of Darnell." One of the most beautiful of the early drawings of this plant is that given by Besler (*Hort. Eystett.* II., 13 *fol. 6, f. 1, published in 1613*). So accurate in fact is Besler's picture that it might be reproduced as a modern sketch. But this is not the only interest in it, for in the text the grain is described as striated, a peculiarity, it may be added, that is possessed alone by the cultivated edible forms of the plant, although no mention is made of its being edible. Miller (*Gard. Dict. 1st Ed. 1731*) would appear to be the first author to indicate a knowledge in the seeds being edible. He remarks that it is "a form of corn often cultivated in Portugal and Italy and other warm countries, where they string the seeds as beads and in scarce years of other grains I have been informed the poorer sorts of people make bread of it, but I do not find it anywhere cultivated for that purpose."

A. D. 1613

A. D. 1731.

The supposed medicinal virtues of the grain are alluded to by most of the early writers, but without exception all dwell on their suitability as beads (Anglo-Saxon, bedes). Parkinson (*Theat. Botanicum, 1640*) ever quaint and interesting, may be quoted as representative of the antiquity and universality of this knowledge.—"It is of little use in Physicke that we can understand in the natural places, or where it may be in more plenty than with us : yet some, as Pena and Lobel say, doe commend it, either in powder or the decoction thereof, against the stone or gravell in the kidnies and bladder ; but beyond sea, the greatest use they make of it, is of the seede, to perforate and string them, as other things for beades, to stint God with their prayers."

A. D. 1640.

Turning from these European records to those of the East, we are informed by the Authors of the *Pharmacographia Indica* that the seeds are "mentioned in Vedic literature and appear to have been one of the cereals which were cultivated by the Arians on the hill slopes of the Himalaya." "The Arab travellers in the East become acquainted with the seeds and named them *Damu Daud* "David's tears," and afterwards *Damu Ayúb* "Job's tears." Es-Saghani, who died about the year 1260, mentions them in the *Obáb* as a well-known strengthening and diuretic medicine. The Arabs introduced the plant into the West, and it has become naturalized in Spain and Portugal, where it is still known as *Lagrima de Job.*"

From Asiatic Sources.

A. D. 1260.

It is significant that the word *kasi* (or some very similar word) should appear and re-appear all over India as the vernacular name for one or other of the forms of this plant. Thus we have the *ka-si*

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From Asiatic Sources.

of the Nágas on the North East frontier of India, *kasei* in the Central Provinces, *kasai* in Guzerát of the Bombay Presidency, *kesai* in Berár and the *cheik* or *kyeit*, *kulese*, and *kalinse* of Burma. The word *ka-si* or *kessi* most frequently denotes a cultivated edible form. This has its parallel in the very general name of Job's tears in the languages of Europe, and may be accepted as indicating a commonality of origin. The Arabs we know have a tradition that Job used the flowers of *Inula* to heal the sores on his body, hence according to them *Inula* and not **Coix** would be the true Job's tears. That expression as applied to **Coix** rests most probably, on the shape of the grains which, as **Gerarde** puts it "every graine resembleth the drop of teare that falleth from the eye." But it is somewhat curious that in no Indian language has the resemblance to a tear been suggested by the vernacular names. In Assam **Coix** is often called *koamani*, that is, crow's jewel.

HABITAT.

Habitat and Distribution :—There are two undoubted wild forms of this plant and several cultivated states. By far the most widely distributed is **Coix Lacryma-Jobi** proper. This is met with (of the provinces of India) in the Himálaya, Rajputána, the Central Provinces, Bombay, South India, Bengal, Assam, Burma, and the Shán States. But its area extends to China, Japan, the Malaya, the American Continent (North, Central and South), the West Indies, Polynesia, the Mascarene Islands and Tropical as also Northern Africa and is cultivated as a garden curiosity in South Europe. It is thus met with throughout the Tropics and in all warm temperate countries. The other wild species **C. gigantea** (and its variety **C. aquatica**) has a much narrower distribution, is a distinctly tropical plant, and practically confined to India and Burma. Of the cultivated (or semi-cultivated) special forms, the cylindrical fruited **stenocarpa** has been recorded as met with in the Nága Hills, Burma, the Shán States, Tonkin and New Guinea. Lastly, the fully cultivated and edible form, **Ma-yuen**, is grown (of the Indian provinces), in the Central Provinces, Sikkim, the Khasia Hills, Burma and the Shán States, and outside India it appears to be cultivated in Tonkin, China and the Malaya, but apparently in no other parts of the world. In his review of Botanical Geography (*Ray Soc. 1846, p. 86*) Prof. **Grisebach** specially refers to the edible **Coix** as a feature in the agriculture of Chusan but makes no mention of its most important area of production—Eastern Bengal, Assam, Burma, and the Malay. In fact were a review of the geographical features of interest of the cultivated plants of British India to be specially written, **Coix** would have to be commented on as a feature of great interest in the tract of country that stretches East by South from

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Nagpur to Sikkim, Assam, Burma, the Malay and China, and to be characterised as an important food grain with some of the most ancient of the aboriginal inhabitants of India.

BOTANICAL FORMS.

Botanical forms :—Mention has been made of certain names given to the forms of **Coix**. It will help to elucidate thé practical and industrial facts, that it is desired to make here known, if some attention be now given to the forms of the plant as recognised and described by botanists.

Number of species.

In the *Flora of British India*, **Coix gigantea** has been treated as a variety of **Coix Lacryma-Jobi,** while **C. aquatica** has been regarded as a form imperfectly known. It seems probable, however, that all three are fairly distinct plants, separable from each other by constant characters. Whether they should be treated as but one species, with several fairly well-marked varieties, or two or more distinct species, may be open to doubt It may perhaps be the safer course to accept them as constituting two species, with under each, several varieties. The best names, if not the most ancient ones, would be **C. Lacryma-Jobi** for the one and **C. gigantea** for the other. The latter is preferable to **C. aquatica** since it has become better known. **C. aquatica** in that case can be retained for a variety under **C. gigantea**, though the plant accepted under that name may very possibly be the more prevalent and more widely distributed form of the two. The species thus isolated are certainly very distinct. They differ in structure of leaf, flower and fruit, etc., as well as in habitat and economic properties The wild states of **Coix Lacryma-Jobi** have the capsular-spathe, generally more or less spherical, and only slightly drawn out at the apex into a pyriform shape, also angled and universally bluish-white (never chalky-white). The leaves are broad, often distinctly auriculate, quite glabrous, except for the double row of ascending teeth, along each of the veinlets of the upper surface—a peculiarity that gives the texture of the leaf the appearance of being embroidered and makes it backwardly hispid.

Differences between them.

The **gigantea-aquatica** series of **Coix** are always wild plants; the former is found on the lower hills—dry soils—a robust erect plant, the latter in swamps and most frequently as a floating weed, 20 to 100 feet in length. The capsular-spathe is invariably pyriform, much drawn out on the apex, the actual mouth cut obliquely into an elongated lip which is often somewhat serrulate, ripe fruit prominently angled, and having two or three furrows along its flattened face, of a dull greyish white to brown colour and also very hard. The leaves are much shorter than in **Coix Lacryma-Jobi**, most frequently only faintly auriculate and the upper (inner) surface often marked by curious transparent glands, which in the young

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COIX Spp.	Coix spp. or Job's Tears.

BOTANICAL FORMS.

leaves are tipped with hairs; on the outside the leaves are quite glabrous except near the extremity of the sheath where a few glands of an exceptionally large size are generally present.

There are other characters in the inflorescence, shape of glumes, etc., etc., that further separate the series of forms under **Coix gigantea-aquatica** from those of **Coix Lacryma-Jobi,** but the above may assist the reader to distinguish them. The features that separate **C. aquatica** from **C. gigantea** will be given in a further passage.

The forms of **Coix Lacryma-Jobi**, in the wild state, have the capsular-spathe invariably bluish-white, a colour which rapidly disappears under cultivation. In the variety known as **stenocarpa** the capsular-spathe is elongated until it becomes cylindrical but when cultivated the tubes (so-formed) change in colour to chalky-white or become almost straw-coloured. In other forms instead of elongating, the capsular-spathe becomes short and spherical until fruits often not more than an eighth of an inch long are found and others more than double that size but always broader than long,—hence the development in these examples may be said to be in the opposite direction to that in **stenocarpa**.

Hardness of shell of seed.

When they exist as wild plants the shell in all forms of **Coix Lacryma-Jobi** remains hard and polished and, while it may darken in colour and become pink, brown or even black, it never is found soft in texture nor chalky-white in colour. But no sooner is it cultivated than it loses the bluish-white colour, becomes soft-shelled, and of a chalky-white or straw-colour to deep blue, brown or black; but in all these cultivated states it assumes a new character, namely, the sheath, on being transformed into the capsular-spathe, retains its veins as pronounced striations so much so as to give the grain (in husk) a striped appearance. In the elongated semi-pyriform states of cultivated **Coix Lacryma-Jobi** there is also a further peculiarity, *viz.*, that a portion at the base of the fruit-spathe becomes constricted into a well-marked annular disk. The condition with a soft and striated shell and basal annulus, appears to constitute the variety known to botanists as **Ma-yuen**—a name given in honour of the Chinese general who is supposed to have first directed attention to that plant.

Coix gigantea, *Koen. ex Roxb. Hort. Beng. 66; Roxb., Fl. Ind. (Ed. C. B.C.) 650;* CATRI-CONDA, *Rheede, Hort. Malab. (1686-1703) XII., 133, t. 70;* LACRYMA JOBI PALUDOSA, *Burm. Thes. Zeyl (1737), 138;* LITHOSPERMUM AMBOINICUM *the* SALEE UTAN, *Rumph. Amb. (1750) VI., 22-3, tab. 9. f.* 1.; is also possibly C. AGRESTIS, *Lour., Fl. Cochin. (1790)*

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COIX GIGANTEA.

I., *551*; C. AGRESTIS, *Kunth. Enum. Pl.* (*1833*) *I.*, *21*; C. STIGMATOSA, *C. Koch et Bouchè, Ind. Sem. Hort. Berol.* (*1855*) *9*; *Voigt, Hort. Sub. Calc.* (*1845*) *710*; C. GIGANTEA, *Koen. ex Duthie, Fodd. Grasses* (*1888*) *18*; C. LINGULATA, *Hack. in Oest. Bot. Zeitschr. XLI.* (*1891*), *5*; C. LACRYMA-JOBI, *var.* GIGANTEA, *Hooker, Fl. Br. Ind. VII.*, *100*; also *Hooker*, in *Trimen, Handb. Fl. Ceylon 192.* Although *Bauhin* (*Hist. Pl.* (*1651*) *II.*, *449. f. 1*) regarded his two plates as representing the same plant, the one exhibits most of the distinctive features of C. GIGANTEA (f. 1 original) and the other (f. 2 *copied from Lobel*) those of C. LACRYMA-JOBI.

Vernacular names :—*Danga gurgur*, BENG. (Roxb.); *ganja, giral, kara, kaurilla*, Dehra Dun, U. P.; *kesai*, BERAR (according to Duthie); *mrigaru riksen*, Garo Hills, ASSAM; *ledau-kyeik, kyeikpu*, KATHA; *kyeikaing*, MYELAT; *marlweir*, SHAN; *bohpreing*, TAUNGTHU, BURM.; *moana karabu* SINH.; *bo-bo hoang*, COCHIN-CHINA; *Judsu-dama*, JAPAN.

Rheede's illustration of the plant he named *Cafre* or *Catri-conda* would seem to belong to this species but as opposed to that view there is the fact that Roxburgh placed it under C. lacryma.

Roxburgh mentions that this species grows chiefly in the valleys amongst the Circar mountains and in Bengal. The Circar mountains are not very remote from the locality where the *Catri-conda* was found by Rheede but it is significant that C. gigantea has only occasionally been since collected in South India. Roxburgh says it is a perennial plant " Culm erect, ramous to the top round, smooth, jointed, from 8 to 15 feet high and as thick as a man's thumb at the base."—" The pedicels," he further says, " are naked; male spikes drooping with flowers threefold, the middle one pedicelled; female corolla six-valved, seeds ovate." His MS. drawing No. 872, preserved in the Herbarium, Calcutta, and a copy in the Kew Library, shows long erect thin branches; leaves linear-lanceolate, acute, margins not hispid, base hardly if at all auriculate, male spikes often long pedunculate and drooping; spikelets slightly spreading, as if racemose rather than spinose; glumes much more elongate than in aquatica and hardly emarginate, often beaked: capsular-spathe or involucre ovate to linear-ovate but quite regularly formed and having an oblique terminal lip. Roxburgh neither described nor figured the glands, occasionally present in this plant, though not so abundantly so as in var. aquatica. The above description and plate constitute however the type to which subsequent determinations have to be referred. Loureiro (*Fl. Cochin-China*) speaks of his C. agrestis as the smooth leaved non-edible form, that is found on the homesteads in dry sandy places and which when experimentally cultivated produces broad quite glabrous leaves.

Distribution.—The distribution of the plant may be inferred from the following record of collections :—

In the Kew Herbarium there are many sheets of which the following may be mentioned :—***INDIA*** : ***South India***, Wight, 1729, 202

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COIX Spp.

Coix spp. or Job's Tears.

COIX GIGANTEA.

DISTRIBUTION.

(A) & (C) also 8625(A) Wallich *ex* Herb. Wight; ***Deccan***—Wallich, No. 8624(C)—*ex* Herb. Heyne, (E) ***Chenapah***, *ex* Herb. Wight; ***Bengal***—Wallich No. 8624 (F) & 8624 (G), *ex* Hort. Bot. Cal.; Prain, ***Parisnath, Bengal;*** Rottler Herb. (*ex* Roxb.); Griffith, ***Afghanistan;*** Forsyth Herb. (*ex* Roxb.); Abel Herb. ***E. Indies*** (*ex* Roxb.); ***United Provinces***—Duthie, ***Shahjahanpur*** No. 5036 (vern. *gunja* or *kaurilla*); ***Burma—Fort Stedman,*** Collett, No. 51, (the type of C. lingulata *Hackel*). ***CEYLON:*** Herb. Rottler. ***JAPAN: Nagasaki***, Oldham No. 861 (924) (*djus-dama*), found on borders of streams—leaves usually broad; No. 369 in the woods—leaves normal; ***Yokohama***—Bennett, *ex* Herb. Hort. Bot. Petropolitani. See paragraph on distribution of var. Ma-yuen—reference to the West Indian cultivated plant, p. 218.

In the British Museum Herbarium, in addition to duplicates of some of the plants already quoted, there are interesting additional examples of this species:—***Bengal***: Mr. C. B. Clarke's No. 20996 from Chaibasa in Chutia Nagpur and No. 24501 from Bárásat: a sheet that appears to have been contributed by Dr. Buchanan Hamilton (No. 1006? collected in Eastern Bengal in 1815)—a beautiful sample of this plant with the glandular-formations on the leaf well marked suggestive of its being possibly variety aquatica: Major Prain's No. 1397 from Monghyr. ***Central Provinces***: Mr. Duthie's No. 8493 a most interesting example the whole plant not exceeding six inches in height and all the structures though thus diminutive, characteristic of the species in every detail. ***Central India***: Gwalior, Mr. C. Maries' No. 159. ***South India***: A very typical sheet from Col. Beddome. ***Ceylon***: a specimen from the Central Provinces No. 942 that may possibly be variety aquatica and Mr. Moon's specimen. There are no examples of this species from any other part of the world.

In the Herbarium of the Royal Botanic Gardens, Edinburgh, have been deposited a duplicate set of most of the collections of Coix discussed in this paper under the heading "Review of Collections recently made in India." But in addition there are many fine sheets that amplify the citations given from the Kew Gardens and British Museum Herbaria. Of C. gigantea the most noteworthy samples are Buchanan-Hamilton's No. 1989 from Eastern Bengal—a superb specimen showing the narrow linear leaves profusely punctuated with glandular structures and the glumes large, broadly winged and deeply emarginate. Hamilton named this plant as C. lacryma, b.: it was collected in October 1811. Then there is Sir J. E. Smith's sheet said to be from Nepál which has gland-dotted broad

C. 1683-1700.

COIX GIGANTEA.

leaves and acute entire glumes. Lastly a sample collected at Dehra Dun No. 8599 (of R. E. P. Herbarium).

DISTRIBUTION.

The Flora of British India gives the habitat as "The hot valleys from the North West Provinces to Assam and southwards to the Malay Peninsula and Travancore, distributed to Afghanistan."

DESCRIPTION.

Description.—The following detailed description may be useful *stem* perennial, erect; *leaves* narrow, linear, shortly acuminate-lanceolate, very slightly cordate-auriculate, *union* with sheath a broad triangular suture, projecting from either margin to the mid-rib, *sheath* long and strongly ribbed but quite glabrous and eglandular; *upper surface* of leaf hairy especially near the tip, glabrous on becoming old; hairs long, stiff, pointed, ascending and each arising from a minute gland which shows through as a swelling on the *under*-surface, and is seen to be a glistening blister on the upper; *margins* of the leaves hyaline with short stiff teeth but old leaves otherwise quite smooth; veins five to seven, on either side of the mid-rib, with the same number of veinlets between each pair of veins. *Inflorescence* profusely axillary, near the extremities of the shoots, usually within each leaf two or more spikes, one with a fairly long peduncle (or stalk) and bearing one or more spikes within a short spathe-like leaf, the other spike shortly pedicelled but devoid of a special spathe of its own; *male* spikes short, erect, few-flowered, racemose, the spikelets in threes, each two-flowered and the lower pair of spikelets sessile, one placed above the other, and the third with a fairly long slender stalk, thrown off to one side. *Rachis* and *pedicels* of the spikelets thin, elongated, angled, scaly, otherwise quite glabrous. *Glumes* ascending, ovate or ovate-oblong, winged on upper half, the lower and outer glumes emarginate, from the wings being prolonged beyond the natural apex; margins of the glumes hard, rigid, and serrulate as on the leaf-margins, only finer. *Capsular spathe* pyriform, mouth only slightly prolonged, oblique, entire, thickened (the character which presumably suggested the name **lingulata** given by **Hackel** to a form of this plant). *Nut* polished, bluish-white to orange or grey and often mottled, thick, hard, flattened on one side, and with two furrows longitudinally on the flat face but not constricted transversely, a condition met with apparently only in *var.* **aquatica**.

REVIEW OF COLLECTIONS RECENTLY MADE IN INDIA.

Review of Indian Collection.

United Provinces: *No. 8599*, from Saharanpur Botanical Gardens, forwarded by the Director of Land Records and Agriculture, under cover of his letter No. 28 of 8th January, 1897, which encloses **Mr. Gollan's** letter. The grass, writes **Mr. Gollan**, is not found wild in the immediate vicinity of Saharanpur but is plentiful in a wild state

C. 1683-1700.

COIX Spp.

Coix spp. or Job's Tears.

COIX GIGANTEA.

in the district of Dehra Dun, and the neighbourhood of Hardwar, where it is found growing during the rains in the rice-fields and damp ground. It is not collected nor does any economic use appear to be made of its seeds. It is known as *giral* and *kara.*

***Assam*:** *No. 8817 (seeds and botanical specimen) and No. 8815.* These came from Gáro Hills, Assam. The seeds are greyish-white in colour and are known as *mrigaru riksen.* It is said to be a wild form and never to be cultivated but grows on the hills. The fruits are used by the Gáros as ornaments only. The name *mrigaru* appears to be generic for all forms of **Coix** in these Hills, the cultivated form being known simply as *mriraku.* (*Conf. No. 8818 and 8821 under* **Coix Lacryma-Jobi,** *var.* **Ma-yuen**).

***Bengal*:** Roxburgh's **Coix gigantea,** he tells us, bore in his day the Bengali name of *danga gurgur*—a name that so far as the collections recently to hand show, would be more correctly applied to **Coix aquatica.** It is further somewhat remarkable that no example of this form has been procured (during the recent investigations) from the Province of Bengal.

***Burma*:** *No. 11805* is a sample of what I take to be this species. It came from the Katha District, where it is known as *ledau kyeik* or *kyeikpu.* The seeds are of a dull, mottled white colour. But the plant sent along with the seeds very possibly does not correspond, and is **C. Lacryma-Jobi.** *No. 12236* has been received from the Eastern Division, Southern Shán States, and it has the characteristic shell and mottled fruits of this species but as no botanical specimens were furnished, it cannot be named for certain. It is said to be wild in Mong Nai and fairly common in marshy land. It is not used for any purpose, but in Burmese it is known as *kyeik-aing*, in Shán *marlweir*, and in Taungthu as *boh-preing.*

COIX GIGANTEA VAR. AQUATICA.

Var. aquatica, *Watt*; Coix aquatica, *Roxb. in Fl. Ind. III, 571; Voigt., Hort. Sub. Calc. (1845) 710.*

Vernacular names.—*Ganrer jail-gurgur,* Beng.; *dhan-gurgur, gurlu, gullu,* Mandla; *Kasai,* Nagpur; *gurlu, gullu, garru, kaldu, kasai, kasud, kachai, kasahi, gargud,* Central Provinces; *kyeik-the,* Pegu; *gyeit-songyu,* Akyab; *geiksi,* Tenasserim; *kayeik, kaleik,* Shan States, Burma.

It may be useful to record here Roxburgh's diagnostic description of this plant. It is a native of the lower part of Bengal, and he says is a "Floating and creeping plant from 50 to 100 feet leaves linear, most acute, with hispid margins; male spikes drooping, many flowered; flowers three-fold, the middle one pedicelled;

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COIX GIGANTEA VAR. AQUATICA.

female corolla from six to seven valved; seeds turbinate." In the Calcutta Herbarium, and in the Kew Library are preserved the original and a copy of Roxburgh's unpublished plate No. 1908. This might be described as showing a plant with swollen stems and floating roots; leaves linear-lanceolate, very slightly cordate, margin distinctly serrulate or hispid; male spikes shortly stalked, very prominently drooping, spikelets three, middle one pedicelled; glumes broad, ovate oblong, often acuminate or apiculate with pale coloured wings or margins. Capsular-spathe irregularly pear-shaped grooved (turbinate) chalky white to dark green or brown. Roxburgh makes no mention, however, of the glandular hairs that are so very characteristic of this plant. The above description and plate must be accepted as denoting the variety aquatica.

Distribution.

Distribution. –The distribution of the plant may be inferred from the following record of collections in the Kew Herbarium that I accept as belonging to this form—***INDIA***, Herb. Hook. f. and T. T., as follows No. 1, T. T., (No. 1447), ***Rowlee Ghat*** 1,000 ft. (October 1845) (a sample showing the long floating roots as in Roxburgh's plate); No. 3, ***Concan,*** Herb. Law; No. 3, ***Mysore,*** G. Thomson; and Nos. 4 and 5, ***Concan,*** Stocks; Jacquemont, Bomb. Karli, Nos. 632 and 569; Wight, No. 202 B; McClelland, ***Rangoon; East Bengal,*** Griffith No. 6451 (a doubtful plant with very compact spikes); Kurz, ***Teenpahar, Bengal*** (in fields); Duthie, ***Central Provinces*** No. 8493; Watt, ***Balasore*** (24-2-83).

The following examples found in the Herbarium of the British Museum may also be mentioned:—Southern Marátha country (***North Kanara***) collected by A. P. Young, Esq., I. N., a beautiful example with the characteristic glandular formations, tipped by deflexed hairs, and with the angled and transversely constricted fruit of this variety all strongly marked. In the Edinburgh Herbarium there are many examples of this obscure variety. These all preserve the characteristics already indicated and support the opinion advanced that so far as India is concerned this particular form, though found on the mountains of Bengal, is much more prevalent in Western and Southern India and Burma than in Northern and Eastern India:—W. H. Campbell's No. 60, from Peninsular India (the label of which bears the name *Vishnu Chukram*) and Dr. Ritchie's No. 870 collected at Belgaum, a duplicate of which appears in General W. Munro's Herbarium.

It would thus seem that while C. gigantea may be spoken of as met with chiefly on the mountains of the Eastern and Central portions of India, the variety to which the name aquatica has been given, occurs on the banks of rivers and margins of marshes, ponds, etc., more specially of Western and South India to Burma and Japan.

C. 1683-1700.

COIX Spp.

Coix spp. or Job's Tears.

COIX GIGANTEA VAR. AQUATICA.

Description.

Description. – The following description is made from the series of Indian specimens I have identified with the above mentioned plant:—*Stem* perennial, floating; *leaves* as a rule short (relatively much broader than in C. gigantea), ovate linear-lanceolate, the upper ones greatly drawn out into long tapering very acute points, broadest near the sheath, very slightly cordate-auriculate, the blade appearing like a direct prolongation of the open loose sheath, and its union with the sheath as a rule represented by a narrow line; sheath thin, not strongly ribbed but very frequently possessing, near the union with the blade (and on the outside) a few large thickened glands with a crater-like depression on the top of each, which corresponds with the point from which a short, stout, deflexed hair has fallen off; *upper surface* of blade densely covered with large conspicuous glands which, in the young leaf, more especially near the tip, bear stout bristle-like, deflexed and rigid hairs, and give the upper surface of the leaf a rough feeling; *under surface* quite smooth; margins of the leaf only faintly serrulate, and chiefly near the base. *Spikelets* axillary, borne on very long, naked, strong, triangular peduncles which, above the fruit, often bear, within the deflexed portion, a tuft of hairs set on hard reddish glands, or the glands alone are present. *Male* spikes elongated, on very short peduncles, hence mostly nodding, many-flowered; they are strictly speaking spikes not racemes, though the spikelets are in threes, the two lateral opposite each other on the rachis and the third in the middle, borne on a fairly long ascending (not spreading) pedicel, each spikelet two-flowered; rachis and pedicels rigid, thick, strongly angled, with, on the margins, a few stiff hairs, bristles or teeth. *Glumes* broad, ovate oblong, acute or beaked, not emarginate, outer one of each spikelet with a strong fold along the inner surface, corresponding to the union of the wings, which acts as a clasping contrivance to hold the inner glumes, very much as in a bivalved shell; margins serrulate, but not very strongly so; spikelets imbricating and coarctating in six rows along the compact pendulous spike. *Capsular-spathe* irregularly pyriform, apex drawn out into a tube that ends in a mouth, obliquely prolonged into an acute lip. When half ripe, surface irregularly warted or corrugated, and constricted transversely near the middle, the upper half being furrowed into some 8 or 10 ridges, ultimately when quite ripe, smooth, hard, polished, angled, and of a dull white or greyish or greenish brown to dark brown colour. It is very hard and is only rarely eaten.

Review of Indian Collections.

REVIEW OF COLLECTIONS RECENTLY MADE IN INDIA.

Deccan, Bombay:—One of the most splendid examples of Coix ever seen by me very possibly belonged to this form

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COIX GIGANTEA VAR. AQUATICA. Review of Indian Collections.

to **C. gigantea.** Whilst on a visit to the Commissioner of Settlements and Agriculture, Bombay, I observed over one of the doors of his house a screen, consisting of chains of **Coix** seeds. These were the largest I had ever seen and were, I believe, from $\frac{3}{4}$ to 1 inch in length. My host (Mr. Lawrence) said he thought the seeds had been obtained locally but he was unable to afford any very definite information regarding them. He has promised to institute a thorough inquiry.

Bengal :*—No. 8760* is the *ganrer* of Palamow, Chutia Nagpur, where it is not cultivated but grows wild in the marshy places throughout the district, or near *dhán* (paddy) fields. Hence perhaps its name *dhán ganrer or dhán gurgur.*

Central Provinces:*—Nos. 8762 to 8770.*—In the Mandla District it is known by the name of *gurlu,* except by the Gonds who call it *garru.* It is found wild near cultivated lands, especially swamps adjoining fields. The samples illustrate the most prevalent forms of the spathe—dull, lurid white to brown, brown or black, being less plentiful than the dull chalky-white. The plant flowers in September; and the fruit ripens in October and is collected in November and December. It is eaten by the poorer classes either boiled whole like rice or is broken in a mill like *dál* and used as a substitute for pulse. There are three forms, namely, white fruits (*Nos. 8762* and *8769*) ; green (*Nos. 8764* and *8767*); and dark brown or black (*Nos. 8763, 8768, 8770*). It is never cultivated. *No. 9698,* received from the Sambalpur District. The Commissioner of Settlements and Agriculture furnished a report for the whole province, on the subject of **Coix** and illustrated the same by specimens. These bear the following vernacular name :—*garlu, gullu, garru, kaldu, kasai, kasud, kachai, kasahi, gargud,* but apparently the different species are not separately recognised by the people. In the report it is stated that in some form or other **Coix** is found nearly all over the province except in the district of Chhindwára. The wild form, differentiated from the others as *dhán gurgur* (*No. 9698*) is common in rice-fields, springing up naturally as a weed. It flowers in October, ripens fruit in November and December, and dries up by February. It grows usually to a height of 2 to 6 feet and may be regarded as the aquatic form and is met with on *bahal* or low-lying fields and also on the banks of *nalas* and edges of tanks. It has a fruit with a hard shell constricted at the top.

While travelling in Nagpur District in 1894 I collected a sample of **C. aquatica** which was called *kasai*; it was found floating on the margin of a tank (*Field No. 13849*). Mr. Duthie also collected a plant in the Sevat Valley at 3,000 feet in altitude (in fruit on the

COIX Spp.

Coix spp. or Job's Tears.

COIX GIGANTEA *var.* AQUATICA. Review of Indian.

17th September 1895) which is the same though the leaves of his plant seem unusually broad, suggestive of **C. gigantea** (*No. 17614*).

Burma :—*No. 10497* is the *kyeik-the* (phonetically spelt *cheik-the*) of the Pegu District, where it is found wild and is used for ornaments and rosaries. This with its large mottled pyriform fruits may well be spoken of as a typical specimen with elongated fruit received from Prome. *No. 11080*, dark brown in colour, has been furnished by the Deputy Commissioner, Amherst, in the Tenasserim Division and described as the wild plant of that locality. *Nos. 11559* and *11560* are samples of elongated fruits, white, deeply furrowed along the face; these came from Tharawaddy, *No. 11583*, known as wild *geiksi*, was received from Tenasserim; it has long, white (milky), angled fruits and prominent glands on the leaves. *No. 12162*, from Akyab, has a large creamy, white fruit. It is said to be wild and has been received under the local name of *gyeit songyu*.

Shan States :—*No. 15061*.—This is a somewhat exceptional form that has come from the Karenni, Southern Shán States under the name of *kayeik* in Lower Burma and *hpaung* or *kaleik* in the Shán States. It has remarkably long erect spikes and the nut is more spherical than usual, the lip ovate acute, spinose, and the fruits of a rich nut-brown or yellowish colour. In some respects this is intermediate between the form that I have above accepted as being **C. aquatica** and that which I have assumed to be **Roxburgh's Coix gigantea.**

COIX LACRYMA-JOBI.

Coix Lacryma-Jobi, *Linn. Sp. Pl. 972*.—LITHOSPERMON, *Pliny Nat. Hist. of World* (*transl. by Holland 1601*) *II., 284*; LITHOSPERMO, *Maiori, Bock* (*Hieronym.*), *latinised to Tragus* (*1552*) *916, lib. 2C. 140*; LACHRYMA-JOBI, *Dodoens, Hist. Frum.* (*1569*) *70, t. 71*; *Lobel, Icon. Stirp. Pl.* (*1591*) *44*; *Gerarde, Herball* (*Ed. Norton 1597*), *81-82 and plate*; Besler, *Hort. Eystett.* (*1613*) *II., 13, fol. 6, f. 1*; *Parkinson, Theat. Bot.* (*1640*) *430*; LITHOSPERMUM ARUNDINACEUM, *Bauhin, Hist. Pl.* (*1651*) *II., 449, 2nd plate* (*ex Lobel*); MILIUM SOLIS or LITHOSPERMUM INDICUM, *J. Bontius, Hist. Pl.* (*ex Piso*) (*1658*), *152*; SESAMO ANNUO, *G. Zanoni, Istor. Bot.* (*1675*), *171-80, t. 68*; LACHRYMA-JOBI, *Morison, Pl. Hist. Univ.* (*1699*) *III., 249, Sec. VIII, t. 13*; LACRYMA-JOBI, *Magnol, Charact. Pl.* (*1720*) *62*; LACRYMA JOBI, *Bœrhaav, Index Pl.* (*1720*) *II., 166*; *Miller, Gard. Dict. 1st Ed.* (*1731*); *Burm. Thes. Zeyl.* (*1737*) *13/-8*; C. LACRYMA, *Linn., Hort. Cliff.* (*1737*) *437*; *Sp. Pl. 1378*; C. OVATA, *Linn., ex Royen Fl. Leyd.* (*1740*) *72*; *Weinmann, Phytanthozaiconogr.* (*1742*) *III., 206*; LACHRYMA-JOB, *G. Zanoni, Rari. Stirp. Histor.* (*1742*) *136-8, t. 101*; *Linn. Fl. Zeyl.* (*1747*) *156*; LACHRYMA JOBI India (*Salee*) *Rumph. Amb.* (*1750*) *V., 193, t. 75, f. 2*; C. LACRYMA, *Thunb. Fl. Jap.* (*1784*) *37*; LITHAGROSTIS LACRYMA-JOBI, *Gaertn. Fruct.* (*1788*) *I., 7, t. 1, f. 10*; C. LACHRYMA, *Lour. Fl. Cochin.* (*1790*) *I., 551*; COIX (LARMILLE) *Lam., Encycl.* (*1783-1808*) *III., 421, I., 750*; C. ARUNDINACEA, *Lam., Encyc. iii 422*; C. PENDULA, *Salisb. Prod.* (*1796*) *28*; C. OVATA, *Stokes, Bot. Mat. Med.* (*1812*) *IV.*,

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COIX LACRYMA-JOBI.

343 ; C. LARMILLE, *Beauv. Agrost.* (*1812*) *137, t. 24, f. 5 ; Aiton, Hort. Kew.* (*1813*) *V., 236 ;* COIX LACRYMA, *Willd. Sp. Pl.* (*1797 1824*) *4, 202 ; Bot. Mag.* (*1824*) *Vol. 51. No. 2479 ; Roxb. Fl. Ind.* (*1832*) *III., 568 ; Kunth, Enum. Pl.* (*1833*) *I., 20, Supp., 16, t. 3 & 4 ; Webb et Berth., Phyt. Canar.* (*1835*) *t. 242, 243 ;* C. EXALTATA, *Jacq. Eclog. Gram.* (*1813-44*) *60, t. 40 ; Miquel, Fl. Bat. Ind.* (*1855*) *III., 476, t. 41B.;* C. LACRYMA, *Steud. Syn. Gram.* (*1855*) *9 ; Church, Food-grains of India, fig. 10 ; Duthie, Fodd. Gras.* (*1888*) *18-19 ; K. Schum. & Lauterb., Fl. Deuts. Schutzg.* (*1901*) *164 ; Hooker f., Fl. Br. Ind. Vol. VII, 100 ; in Trimen Handb. Fl. Ceylon, 192.*

Vernacular names.—*Gurgur, jargadi,* BENG ; *jargadi,* SANT ; *sankhru, sankhlu, gargari-dhan,* HIND.; *kaiya, sankru, baru,* U. P. ; *sanklu,* SIMLA, PB. ; *dabhir,* MT. ABU, RAJ. ; *gandula, garun, kasei, gulbi-gadi, gurlu,* C. P. (according to Duthie) ; *Ránjondhala, ranmakai ;* MAR. (according to Dymock) ; *kasai,* GUZ. & PANCH MAHALS, DECCAN ; *koamonee, kawrmonee,* ASSAM ; *sikra kraou, koa sangti,* NAGA HILLS ; *jhonki, dhola-jhonki, kawa-jhonki,* CACHAR ; *mim,* LUSHAI ; *chang-nim-khombi,* (the edible form being simply *nim* or *num*) MANIPUR ; *gyeik aing, gyeik-yaung, gyeiksi-aing,* BURM. ;* *keekirrindee karœbu,* SINH. ; *salee,* AMBOINA ; *jale* or *djali,* JAVA ; *tômugi,* JAPAN ; *gavidhuka, gavedhu, gavedhuka* SANS. (according to Dymock).

Roxburgh gives the following description of this plant :—" Leaves at base cordate ; pedicels naked, not jointed ; male spikes nodding ; flowers paired ; calyces smooth, ovate." Loureiro lays special stress on the recognition of a cultivated state of this species, as being distinct from the wild plant, and to the latter he gives the name of **C. agrestis** (a plant which I believe may have been **C. gigantea**). Rumphius also figures and describes a cultivated form (the *salee* of the Malayas) and affirms that it is a distinct plant from the wild condition *salee utan.* His cultivated plant is probably the variety below named **Ma-yuen,** and his wild plant I believe to have been **C. gigantea** though it is somewhat remarkable that Roxburgh makes no reference to it.

Distribution.

Distribution.—The following record of samples examined by me gives direct information regarding the distribution of the species :—

INDIA :—***United Provinces***—Udaipur, Duthie, No. 50 (vern. *kaiya*) ; Gurhwal No. 5037 (alt. 3,500) ; Kumaon, Strachey and Winterbottom (3,500 feet) ; ***Bengal***—Noakhally, Herb. Ind. Or. Hooker f. and T. Thomson No. 2 ; Forsyth (*ex.* Roxb.) ; Megna, Herb. Ind. Or. Hooker f. and T. Thomson No. 2 ; Griffiths, Eastern Bengal, 6447 ; Sikkim, Herb. Ind. Or. Hooker, f. and T. Thomson No. 2 (5,000 ft.) ; ***West*** and ***South India*** : Deccan—Herb. Wight (No. 1730) named **C. exaltata,** *Link.* Herb. Rottleriana, from Mysore named **C. latifolia,** *Nob.* ; Ootacamand, Herb. Munro. ***Assam*** : Sylhet and Khasia—Herb. Ind. Or. Hooker f. and T. Thomson No. 3

* By a more common transliteration these Burmese names would be rendered *Kyeik-aing, Kyeik-yaung* and *Kyeik-si-aing.*—ED.

C. 1683-1700.

COIX Spp.

Coix spp. or Job's Tears.

COIX LACRYMA-JOBI. Distribution

(alt. 6,000 ft.); Wallich, Sylhet, No. 8623 (F.), ***Burma***: McClelland, Rangoon; Wallich, Penang, 8623 (K.) and (L.); ***CHINA***: A. Henry, Ichang, No. 2635; Hong Kong—Bot. Gardens No. 195. ***JAPAN***: General Munro, in woods—a long leaved form with pointed grain somewhat like those of **C. gigantea,** but no glands or other distinctive characters of that species. ***MALAYA***: Perak—King's collector No. 7212, a remarkable plant with long erect compact spikes, that deserves being viewed as a distinct and undescribed species. It is alluded to here provisionally. Tonkin—Balansa, No. 4897, typical example;—Ins. Philip; Timor, Herb. Mus., Paris; ***TROPICAL AMERICA***: S. Pacific Explor. Exped.; Yucatan—from Columbian Museum, No. 1031; Brazil (No. 67) and Peru (No. 1644), samples with leaves hardly cordate and leaf sheaths often hardened but somewhat as in the variety **Ma-yuen**; Burchell's No. 3628, has very long leaves hardly cordate; Pearce's samples from Corocoro have leaves, long narrow; Bolivia, Britton and Rusby, No. 527. ***WEST INDIES***: Antilles and Porto Rico—E. Hackel, No. 356. St. Vincent—damp situations near the sea—"Is called *Job's tears* in Brazil" where the seeds are used for rosaries called "lagrimas de Santa Maria"; Martinique. ***POLYNESIA***: Fiji Islands—Seemann, No. 692, grain slightly elongated; Tongatabu Isld. Challenger Exped. Samoa Rev. T. Powell (*ole sanasana*, vern.) typical; Rev. S. J. Whitmee's sample shows tendency towards **stenocarpa**; Balansa's No. 884 named var. **exaltata** is perhaps a cultivated state in transition passing into **Ma-yuen,** grain bluish-white, pointed, very abundant: Treasury Island No. 328 (vern. *ken-ken*); ***MASCARENE ISLANDS***: Madagascar—Rev. R. Baron No. 2514; Hildebrandt, Nos. 1732 and 2934; C. Holst, Flora von Usambara, No. 2226. North African area; Canary Islands:—(E. Bourgeau No. 147). ***TROPICAL AFRICA***: Sierra Leone, G. H. Garrett: Mohilla Island, Livingstone's Zambesi Exped., Sir J. Kirk; Johanna Island, C. J. Miller, Livingstone's Zambesi Exped.

Possibly a new species.

In the British Museum Herbarium there is a large assortment of the typical state of Job's tears of which the following may be specially mentioned in amplification of the distribution indicated by the enumeration of the series preserved in the Kew Herbarium:—***INDIA***: Darjeeling, Mr. C. B. Clarke's No. 12383; Wallich's No. 8623(A) said to have been obtained from Roxburgh; a specimen named **C. lacryma, var. exaltata.** *Link*, Hort. Berol. No. 1253; Mercára, Coorg, collected by R. F. Hohenacker, No. 606. ***MALAYA***: Banks and Solander's specimen; Singapore, also Sungei Ujong, collected by H. N. Ridley; Johore by J. B. Fielding; JAVA: Zollinger's No. 353; Perak, by Smith; Celebes: Macassar, collected by

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Barclay. ***CHINA***: Specimen by H. F. Hance No. 402; ***JAPAN***: Zollinger's sample presented by Shuttleworth. ***S. AMERICA***: Dr. Alven's sample from Surinam. ***WEST INDIES***: Trinidad, collected by A. Fendler, No. 930. ***POLYNESIA***: Bank's and Solander's specimen; Seychelles collected by E. P. Wright; Fiji, by Harvey. ***AFRICA***: Angola, by Welwitsch, Nos. 5004 and 7241; Johanna, by Hildebrandt No. 1732, Giryama & Tsimbu Mountains by W. E. Taylor; Madeira, *ex* herb. R. L. Lowe. ***MASCARENE ISLANDS***: Rodriguez by Prof. Balfour.

In addition to some of the samples already mentioned the Herbarium of the Royal Botanic Gardens, Edinburgh, possesses the following examples of this form:—***INDIA*** from Bengal, Chutia Nagpur, Rev. Dr. Campbell; from Parisnath hill, collected by A. Watt in 1876; Assam samples by Jenkins, Masters and Griffiths (*ex* Herb. Calc. also Ball); the Himálaya, Simla by Dr. Johnson, Bashahr, Lace, No. 1122, N.-W. Himálaya, Duthie; Rajputána, Mr. Duthie, No. 6742. ***CEYLON***: Mr. Brodie. ***MALAYA***: Singapore, *ex* herb. Cleghorn. ***MASCARENE AND OTHER ISLANDS***: Mauritius, *ex* herb. J. Ball; Ascension Islands, *ex* herb. H. J. Gordon; Madagascar, G. F. Scott-Elliot, No. 2237. ***WEST INDIES***: Trinidad, A. Fendler No. 930. ***SOUTH AMERICA***: Ecuador, W. Jameson No. 709.

I have already briefly indicated the main characteristics of this form, in the introductory note, and need not repeat what has there been stated. All the forms of this species are at once recognised by the texture of the leaf, and its peculiar scabrosities. The capsular-spathe varies very greatly and there are in consequence perhaps four well-marked varieties the characters of which are as follows:—

(*A*).—*The normal form* which exists in a wild state and has a spherical to ovate-oblong capsular-spathe, smooth polished, very hard and almost invariably bluish-white in colour.

(*B*).—*The cylindrical form* known as **var. stenocarpa** in which the capsular-spathe is greatly elongated, bluishwhite and cut off abruptly at both extremities; when cultivated it becomes thin and straw-coloured.

(*C*).—*A flattened spheroidal form,* which, as a rule, is broader than long. I propose for this condition the varietal name **monilifer**, because of its extensive use for and peculiar adaptability to the purposes of ornamental beading. All the examples of this variety are abruptly cut off at both extremities, and if not actually depressed, they have very often a large gaping mouth. They manifest a wide range in colour from chalky and milk-white to pink, to brown or even black. They are sometimes cultivated but are very exceptionally eaten,

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Both the largest and the smallest forms of **Coix Lacryma-Jobi** are met with in this series.

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(*D*).—Lastly, there is *an extensive series of cultivated forms* that fall naturally under the variety **Ma-yuen.** These all agree in certain peculiarities while differing widely in other respects. They are universally cultivated edible plants; the shell is thin and easily broken between the fingers, is longitudinally striated, and in most forms there is a basilar portion constricted into a distinct annulus or disk. But in point of colour they manifest but one peculiarity in common, *viz.*, that they are never milky white. The lightest coloured forms are chalky-white (and these appear never to possess the annulus); straw-colours are very common; particoloured grains (dark brown at the base and straw-coloured at the apex) are frequent; blue, striated with brown furrows, are abundant and lastly brown and black are not unusual. The presence or absence of the annulus would seem to denote almost a subvarietal character since all the grains devoid of that structure are spherical in shape while those possessed of the annulus are much elongated and often irregularly pyriform.

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REVIEW OF COLLECTIONS RECENTLY MADE IN INDIA.

A very large series has been brought together from all parts of India and Burma. These may be most effectively discussed under the varietal groups already established.

1st var. typica, *Watt,* Coix Lachryma-Jobi *(proper) Watt in Programme of Collections for the Indian Museum, Calcutta, and the Imperial Institute, London 1897-98.* The following notes indicate the collections to hand of this form assorted according to Provinces of supply :—

Bengal.—*No. 7681* came from the Bankura District, where it was found wild. The Santáls inhabitating that country recognise the plant under the name of *jargadi*, while by the other inhabitants it is more commonly known as *gurgur*. It is used occasionally in the way of garlands and pendants, in dress and fancy basket ornamentation.

Himalaya.—While on tour in the Sikkim and Darjeeling Districts I collected the plant in fruit (November 1900) at Chengtung (*Field No. 14216*). So again far to the west the identical same plant was found by me, growing wild on the banks of a stream, at Nirmand in the Kulu District, Panjáb, at an altitude of 4,000 feet (*Field No. 13418*).

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Assam.—*No. 8128* has been received from Nowgong. It is there called *koamonee* and grows spontaneously near rice-fields. This particular sample curiously enough shows an equal admixture of both the bluish and the milky white grains, a difference attributed locally to transitional stages. The plants come out in May and June, bear fruit in July and August and are fit for reaping in October and November. But so far as has been ascertained the grains are not put to any economic use. *Seeds No. 8278* (*botanical specimens No. 8709*) from Sibsagar, are stated to have no economic use in the district; the plant grows as a weed of cultivation in fertile lands and is known as *koamonee*. Specimens of headchains, as used by children, were submitted but the remark was made that they are not in much demand among the people in the plains though the Nágas seem very fond of them. *Seeds No. 8309* (*and necklace No. 8310*) from Lakhimpur were received under the vernacular names—*koamonee* or *kawrmonee* in Assamese, *koa sangti* by Nágas, *argor* (probably a corruption of the Bengali name *gurgur*) by the colonised coolies on the Bengal side of the district. The plant is never cultivated but is found wild and in abundance on the hills near the banks of streams or margins of bhils (ponds). The plants generally begin to come out in May and June and reach a height of two to five feet. So luxuriant is their spontaneous growth that clumps may usually be seen averaging from five to thirty stems, and, if pruned, more than forty stems may shoot from the common stalk. These bear fruit in September and October, the yield being correspondingly heavy, since each bush may give more than a seer (two pounds) of grain. The fruits in the first stage are greenish but turn to brown or even black and become very hard. The Deputy Commissioner of Lakhimpur states that the young leaves of the plant are much used as fodder for cattle and elephants, the latter being reported as especially fond of them. In Lakhimpur, beadchains of **Coix** are little in favour, except with children and a local superstition militates against their general adoption, for the popular belief holds that "he who wears a **Coix** necklace will lose his blood."

The Deputy Commissioner invites attention to what he describes as "the fallacy of the remark (quoted in *Kew Bulletin*, 1888, 145, and reproduced in *Dict. Econ. Prod.*, Vol. II, 493) and which was made originally by Mr. Bruce of Balipara, namely, the explanation of the vernacular name of *kawrmonee* as Crow's Bead, from the fondness of these birds for the berry." This, it is further contended, is no doubt "an error since there is no berry nor any nutriment in the grains of a kind to attract crows. A more accurate rendering of the term would be to call it "Crow's jewel (just as we say a toad's-stool)." *Seeds No. 8316* (*and botanical specimens No. 9701*) have been

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received from Jorhat under the vernacular name of *koamonee* (more correctly *koamani*) and the plant is there stated to be wild. The nuts are used for necklaces and other ornamental purposes but the use is, as in Lakhimpur, confined chiefly to the children. *No. 872* is from Cachar. This species is there called *jhonki*, *dhola-jhonki*, also *kawa-jhonki*. It is known in Manipur as *chang-nim-khombi* as distinguished from the edible form which is known as *nim* and *num* simply. The plant grows near homesteads as well as in the jungles and springs up during the rains, but is never cultivated. The particulars regarding its economic uses are the same as in other parts of Assam.

The Deputy Commissioner of Kamrup forwarded a botanical specimen of the typical form of **Coix Lacryma-Jobi** unaccompanied with any separate consignment of seeds, and he remarked that the plant furnished was the only indigenous variety or **Coix** available in the district. It is reported to be very scarce, to grow in damp situations and to be used by the native physicians for certain medicinal purposes in cases of children and cattle. But no definite information was furnished regarding its special medicinal application nor has the statement of its use been confirmed by other local officers. In the Darrang District **Coix Lacryma-Jobi** is known by the characteristic vernacular name of *kowar-moni;* it grows spontaneously in shady places and wet soils. But apparently it is little known to the people. Of the Goalpára District it has been reported that it is not known at all, which seems a highly unlikely circumstance. *Seeds No. 10489* (*botanical specimens No. 10216*) from the Nága Hills. This manifests the typical condition of **Coix Lacryma-Jobi** and it is affirmed that this particular form is recognised under the local name of *sikra kraou*. The plant is not cultivated but grows spontaneously in moist fields and damp jungles. The Nágas use the grains for children's necklaces and other personal adornments. For the ornamentation of articles of personal dress, however, the elongated or cylindrical form (**C. Lacryma-Jobi**, *var.* **stenocarpa**) is that most in demand. In Manipur, as stated above, the oval-seeded form of **Coix** (the typical form) is known as *chang-nim-khombi* but is held to be of little account.

Central Provinces.—*No. 9697* from Sambalpur is a sample characterised by deep furrows running across the surface of the fruit and giving it a somewhat angular appearance. This condition is no doubt suggestive of a tendency towards the **gigantea-aquatica** series but in every other respect the sample may be accepted as representing the typical condition of **Coix Lacryma-Jobi**. It is very hard and finely polished and is used for the purpose of ornamentation by children, and sometimes by the adults

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of aboriginal tribes who employ the fruits in place of glass beads. In Hoshangabad, Gond and Kúrkú boys wear the grains in the form of necklaces, while girls of tender age string a few together and make nose-rings of them. The same practice prevails to some extent in Bhandára. The plant grows on highlands and when in a green state is utilised as fodder for buffaloes and other cattle. Elephants are said to be very fond of it, particularly in times of drought. The stems, when dry are used for thatching *pán* (betel) leaf-houses, and even as ordinary thatch, especially for repairing purposes. When green and pliant, the thin stalks are used to tie up bundles of rice at reaping time. It has, however, no special vernacular name to distinguish it from the other and more common form of wild **Coix** in this province, *viz.*, **C. gigantea**, *var.* **aquatica**.

Burma.—*No. 10881* is from Akyab. No particulars have been furnished regarding it. *No. 10892* from Kyaukpyu in Arakan, has been received under the vernacular name of *gyeik aing*. It grows wild and is used by the Chins as beads for necklaces, and in the ornamentation of belts, etc. *No. 10897* from Pegu subdivision in Lower Burma. In his report regarding that sample, the Deputy Commissioner states that the plant is not indigenous in the Pyuntaza subdivision, where the seeds are nevertheless largely used to adorn the dresses of the Karen women at Nauza. But these remarks apparently refer to the cylindrical variety or **C. Lacryma-Jobi**, *var.* **stenocarpa**, and not to the plant furnished. *No. 10946* from Tavoy is reported to be found wild on the sea shores and to be used for necklaces and rosaries. *No. 11122* from Tharawaddy. It was forwarded by the Deputy Commissioner as an edible pear-shaped form. No distinctive vernacular name was given and it is probably by an oversight only that it has been described as edible. *No. 11801* a packet of seeds accompanied by a botanical specimen; these manifest the characteristic features of **Coix Lacryma-Jobi**, *var.* **typica**. *No. 15058* from Mergui is the typical form of **Coix Lacryma-Jobi**.

Shan States.—*No. 12240* from the Eastern Division of the Southern Shán States. It is said to be found wild in Hong. It is there put to little use. But in the Kengtung Division the seeds are utilised to a certain extent for the head-dresses of the women belonging to the Kaw tribe. These head-dresses are in the shape of a rough crown in three tiaras, elaborately ornamented with the seeds of this **Coix**. These head-dresses not only vary in shape in the different clans but unmarried girls are distinguished from matrons by certain peculiarities in structure of the head-dress. Besides these crown-like head-dresses there is another head ornament of a

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long, conical shape. It is by no means easy to obtain samples of these ornaments owing to the fact that every female, whether gentle or simple, has but one, and is consequently very unwilling to part with it. These head-dresses are, in addition to **Coix** seeds, ornamented with silver, beetles' wings, and squirrels' tails.

2nd *var.* **stenocarpa,** *Stapf in Kew Bulletin, 1888, 144-5; Hooker's Icones Plantarum, VIII., Pt. 3, pl. 1764; in Hook. f., Fl. Br. Ind. VII., 100;* C. STENOCARPA, *Balansa in Journ. de Bot. (Paris) IV., (1890) 77; Griffith Not. III., 10;* C. TUBULOSA, *Hack. ex Warb. in Bot. Jährb. XIII. (1891), 260.*

Vernacular names :—*Sikra kracha, sikra krada,* NAGA HILLS; *shamshaw,* NORTH ARAKAN; *chumna-gyeit,* AKYAB; *sitya, kachin-kyeik,* KATHA. *hareik-she, kyeik-padi,* MYELAT; *maklwe-yau,* SHAN; *bongywe,* TAUNGTHU, BURM.

Distribution.

Distribution.—The following may be given as a brief statement of the examples of this plant in the Herbarium of the Royal Botanic Gardens, Kew. The enumeration usefully exemplifies its distribution:—***INDIA. Burma.*** Mergui Griffith, No. 6450 (very short, swollen form); Wight's sample from Griffith Herb.; Kurz, No. 1135 from Pegu Yomah; Watt (24th December 1887) said to be used by Karens to ornament their garments, and by the Angami Nágas to decorate their ear-rings. ***MALAYA.*** The specimens collected by Balansa in Tonkin carry the plant beyond India; it has also been collected in British New Guinea, *viz.*, between the South coast and the Owen-Stanley Range (by Burke), a specimen with a cylindrical-spathe but rather swollen, smooth and bluish-white.

In the British Museum Herbarium there is only one sheet of this form and that contributed by the Reporter on Economic Products to the Government of India. It was obtained from Burma in connection with the inquiry conducted in 1887—already mentioned. But there is a sheet of a plant from ***POLYNESIA,*** Fiji collected by Moseley that might be described as a transitional form between *vars.* **monilifer** and **stenocarpa.**

In the Edinburgh Herbarium will be found by far the finest series of specimens of this variety to be seen anywhere in Europe. It contains an exact duplicate of the Calcutta set of collections made in connection with the production of this report as also my private collections from Burma and the Nága Hills. One sample from Burma shows this plant to be a tall reed with stems as thick as the forefinger.

This variety is not described in Roxburgh's *Flora Indica.* The following may be given as a detailed description drawn from the extensive series in the Herbarium of the Reporter on Economic Products:

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COIX LACRYMA-JOBI *var.* STENOCARPA.

Description.

Description.—*Leaves* broad, linear-lanceolate, gradually tapering into a long strong, sharply pointed tip, hardly if at all cordate at the base, *union* with the sheath a broad, triangular, discoloured suture, projecting from either margin to the mid-rib, *sheath* strongly ribbed, *upper surface* of the leaf quite glabrous and eglandular but traversed by numerous minute nervules which are hardly distinct from the nerves and these manifest (especially when young) very minute ascending teeth or thickened processes, especially along the length of the two or three nervules on either side of the mid-rib; these nervule teeth give a scabrid or hispid character to the upper surface of the leaf, quite absent from the under-surface; *margins* with a very characteristic serration, the teeth much longer and flexuose than in the preceding form, and having in addition two or three nervules (both on the upper and under-surface and close to the margin) that show fairly strong serratures (especially on the upper pointed extremity), so that the margin becomes thickened, involute and formidably barbed. *Inflorescence* prolific from the upper half of each stem; *spikes* axillary, two or three from each sheath producing peduncles that bear leaves with sheaths that give birth to one or two similar spike-bearing sheaths; *male* spikes short, lax, few-flowered, racemose; the spikelets in threes, the central with a long slender pedicel, the others subsessile; rachis and pedicels angled, very minutely serrulate along the angles, otherwise quite glabrous; *glumes* ascending, narrow, ovate or lanceolate; wings narrow, the outer ones often with the tip flattened out spathulately. *Capsular-spathe* cylindrical, often swollen in the middle, and constricted near both extremities, hard, polished, white, mouth cut almost square across and constricted.

It cannot be a separate species but is a variety.

Balansa is very emphatic that this plant should be treated as a distinct species, not a variety. If one or two specimens only are seen Balansa's opinion would be readily corroborated. But when a series of hundreds are brought together it becomes evident that the elongation of the fruit-spathe takes place very often in plants that at the same time bear fruits of the typical **Lacryma-Jobi** form. Further the panorama of forms connect inseparably **stenocarpa**, **monilifer** and **Ma-yuen** with the type of this species. The structure of the leaf and flower is identical in all.

FORM A.

Under this variety among the specimens on my table there are three distinct sets of forms:—

(A)—Very hard, bluish-white, irregularly shaped, swollen in the middle, often curved and mottled in colour.

Burma.—*No. 10885* from Akyab—is a short thick grain $\frac{1}{2}$ an inch by $\frac{3}{10}$ of an inch in length. It is constricted towards the lower

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extremity only and is of an irregular character both in shape and colour—some being long, others short and thick, still others curved, in color white, bluish-white or grey-brown. It is stated by the Deputy Commissioner to be a very late form, the plants surviving up to the middle of March, while the others wither up by February; it is locally recognised under the name of *chumma gyeit*. *No. 10890* varies in colour from steel-grey to brown; it has been received from North Arakan, under the name of *shamshaw*. It is longer and thinner than the previous sample and is cultivated by the Chins to a small extent and used for purposes of ornament. The seeds are simply strung together on threads either consecutively or alternately with glass beads, single rows of these being worn as necklaces. *No. 11584* from Katha, where it is known as *sitya* and is found wild on the Kachin hills. It is used for ornamentation, and is usually nearly ¾ of an inch long. *No. 11804* is a similar sample from Katha received under the name of *kachin-kyeik*.

Shan States.—In these States the cylindrical grain seems to be fairly extensively cultivated, and to be almost a regular article of trade. *No. 12233*, from the Myelat Division, Southern Shán States, shows a thick grain much swollen in the middle. It is known as *kareik-she* (or long *kareik*) or *kyeik-padi* and is regularly cultivated. The plants are grown as a border round paddy fields and are sown in May and June and reaped in November and December. They are not edible but are used for ornamental purposes and are more expensive than the edible forms; price 4 to 8 annas per 1½ viss (1 viss=3·65lb. Av.) while the edible grains fetch 1 to 2 annas for a like quantity. *No. 12337*, received from the Eastern Division, Southern Shán States, where it is found wild in gardens, having been apparently cultivated at some former time. It is known as *kyeik-she* or *kareik-she* in Burmese, *maklwe-yau* in Shán, and *bongywe* in Taungthu. It is also an abundant wild plant in Kengtung. It is said to be cultivated in some districts to a limited extent. The practice is to sow the seeds of both the round (monilifer) and cylindrical Coix in village gardens or on the edge of fields. The sowings are made at the beginning of the rains and the seeds ripen in November. The plant also springs up self-sown long after cultivation has been abandoned. *No. 15059*, from the Karenni Division of the Southern Shán States, received under the name of *kyeik* where it is cultivated and used exclusively for ornamental purposes. It is mainly employed for decoration of the shoulder bags which are so universally used by the Shán tribes. The bags in Kengtung and Karenni are different from those in the west of the Salween river, while the bags made in the lake districts of Ywang Hwe are the best of all. The seeds are never dyed. They are short, thin and cylindical.

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COIX LACRYMA-JOBI. *var.* STENOCARPA.

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(*B*)—This might be spoken as the soft-shelled series of **stenocarpa**, in which the capsular-spathe is straw-coloured, very long and thin, and easily broken between the fingers. These correspond, in the **stenocarpa** series, to the **Ma-yuen** grains except that they are never edible.

Burma.*—No. 37* from Prome is constricted towards both extremities very much as in the Nága form described below under *No. 10215*, but is much paler coloured and softer. It is $\frac{3}{4}$ of an inch long, by $\frac{1}{8}$th inch thick. *No. 11800*, also from Prome, is perhaps the longest specimen received, being fully an inch long and much like short pieces of straw. *No.* 72 from Tharawaddy is nearly an inch long, but in other respects very like the sample from Prome. *No. 11561*, also from Tharawaddy, is one of the longest, thinnest and most cylindrical forms as yet received.

Shan States.*—No. 12233-1* from the Myelat, Southern Shán States, is milky white, hard, short but very uniform in shape and size.

(*C*)—*Transitional forms of* **stenocarpa**.

TRANSITIONAL FORM C(i).

Burma.*—No. 10896* is a remarkable form from Pegu that has the fruits so short that they can hardly be regarded as cylindrical. They are only twice as long as broad and not more than $\frac{1}{4}$ inch in length. Still I have little difficulty in persuading myself that this particular sample represents a transition between **Coix Lacryma-Jobi**—variety **stenocarpa**, and the variety **monilifer** below.

TRANSITIONAL FORM C(ii).

Naga Hills.*—No. 10488.* This interesting sample was furnished by the Deputy Commissioner, Nága Hills (under cover of his letter No. 1320G., dated 24th November 1897). It is one of the series of five cultivated and three wild forms of **Coix** sent from that locality. The wild forms are recognised in the Nága Hills under the generic name of *sikra* in contradistinction to the cultivated forms which are known as *kessi.* The sample *No. 10488* is a short thick condition ranging from $\frac{1}{4}$ to $\frac{3}{8}$ths of an inch and merges into the ordinary form of **Lacryma-Jobi.** It is called *sikra kracha.* This is used for ornamental purposes, especially in making earrings. It is not cultivated but springs up naturally sometimes on the margins of fields but more frequently in the jungles. *No. 10490* (*Botanical specimens No. 10215*) is a second form more distinctly cylindrical and said to be known in the Nága Hills as *sikra krada.* The capsular-spathe is constricted at both extremities in a somewhat striking manner; it is from $\frac{1}{2}$ to $\frac{3}{4}$ inch long. This kind is chiefly used for making necklaces along with the ordinary form of **Lacryma-Jobi** which is called *sikra kraou. Conf.* **Coix Lacryma-Jobi**, *var.* **typica** *No. 10216*), *p. 208.*

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3rd *var.* **monilifer**, *Watt;* described without a scientific name in *Watt, Dict. Econ. Prod. 1887, ii. pp. 493—494;* C. LACHRYMA-JOBI, *var.* GLOBOSA, *Tod. Ms. in Herb. Kew.*, also C. PUELLARUM, *Balansa, in Journ. Bot.* (Paris, 1896) IV., 77.

Vernacular names :—*Le kyeik, kyeik-thi, ke-paung*, KATHA ; *langli, bewnu, burumpo*, NORTH ARAKAN ; *gyeit-thandu*, AKYAB, *kariek-lóng*, SHÁN STATES, BURMA.

Distribution.

Distribution.—It seems probable that the review of information furnished in the Dictionary (l.c.) was the first direct account of the flattened spheroidal form of **Coix** that it is intended to separate under the name **monilifer**. The following exhibits very briefly the more striking examples preserved in the Kew Herbarium, and at the same time denotes the distribution of the plant :—***INDIA : Burma***—Maymyo, Prain's 271; Tavoy, Wallich's No. 8623 (G) and (H) and possibly also (L). These are the only Indian examples in Kew of this exceedingly abundant plant. ***MALAYA*** : Malacca : Griffith No. 6448 ; Luzon Philippine Is. Cuming, 448 (not typical) ; Rio Tanco collected by A. Loher. Tonkin—B. Balansa (No. 1693) small round (flattened on top and bottom), white grain, determined according to label to be **C. puellarum**, *Balansa*). ***CHINA :*** Dr. A. Henry, No. 7567, flattened reddish-white, smooth grain ; Herb. Hort. Petropolitani→large leaved **Coix** with globose flattened grain much like many Indian examples of **monilifer** ; Manchuria—a large globose grain, steel grey to blue, hard, smooth, —called "Righteous Man's grain," used as rice and sometimes strung like beads. Is said to be cultivated ; ***JAPAN*** General W. Munro, ditches and rice marshes, grain dull white, perhaps a form of **Coix Lacryma-Jobi** proper and not **monilifer**. ***AMERICA :*** Mexico—collected Dr. E. Palmer (No. 1337) in grain, this is I think the present plant, but the leaves are long and narrow, not at all auriculate, but at the same time they are quite devoid of hairs or glands, so that it is not **Coix gigantea**—by the label it is said to be "**Coix arundinacea**, *Lam.*," a synonym for **Coix Lacryma-Jobi**. ***EUROPE***: Todaro (*Flora Sicula Exiccata*)—a remarkable plant with large globose fruits and thickened leaf sheaths. It is named **Coix Lacryma**, *Linn., var.* **globosa**—a name never published.

As amplifying the distribution still further, the following additional examples may be mentioned, preserved in the herbarium of the British Museum. ***INDIA*** : ***Assam*** : Griffith's No. 1375, a chalky-coloured grain slightly striated, that may be one of the hard-shelled forms of **Ma-yuen**. ***Nepal*** : Wallich's No. 8623 (G). ***MADEIRA*** : Banks and Solander's specimen collected in 1768. ***MALAYA*** : Singapore : a sample collected by Walker which may

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COIX LACRYMA-JOBI. *var.* MONILIFER.

be accepted as intermediate between the typical **Lacryma-Jobi** and *var.* **monilifer**. Borneo: an interesting plant collected by **J. Whitehead**, which has small milky-blue fruits almost intermediate between *vars.* **monilifer** and **stenocarpa**. ***AMERICA*:** Brazil: a sample presented by **R. J. Shuttleworth** that has the fruits very much as in **monilifer.**

The Edinburgh Herbarium contains a very much more representative assortment of this form than can be seen in either of the above mentioned collections, because of its containing a fairly complete set of the plants specially brought together in connection with the investigations recently conducted by the Reporter on Economic Products to the Government of India. In addition to these there is a plant collected by **Madden** at Dehra Dun (No. 817) that is worth being mentioned as also one from China collected by **Carles.**

Description.

Description.—The flattened spheroidal form may be said to constitute the connecting link between the typical **Coix Lacryma-Jobi** and the variety **stenocarpa**. In fact the plants that I have placed in this position may almost be said to pass imperceptibly into the short fruited forms of **stenocarpa**. The *leaves* are identical with those of the type (**Coix Lacryma-Jobi**), only as a rule they are shorter and broader. The *male* spikes are very slender and versatile; the *glumes* small, narrow, pointed, scarcely winged. *Capsular-spathe* spherical, broader than long, flat on both extremities, the mouth large, gaping, and instead of a basilar annulus there is a circular depression which becomes a perforation. In colour they are bluish-white, steel grey, straw-coloured, pinkish brown or black. They are always exceedingly hard, smooth, polished, never striated and though sometimes elongated until they are longer than broad, they are never pyriform, not possessed of a beak or elongated upper extremity.

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Burma.—*No. 11589.* This is a beautiful, pinkish brown grain, received from Katha where it is known as *kyeik-thi*. It is about $\frac{1}{6}$th of an inch in diameter and almost perfectly spherical in shape. It is found wild in the Kachin Hills. The seeds are used for beads and ornamental purposes for which their flat extremities and large well defined central perforation render them eminently suited. *No. 11588* also from Katha is an exactly similar grain to *No. 11589*, except that the capsular-spathe is pure white instead of pinkish brown. *No. 11586*, also from Katha, is a very large straw-coloured, flattened spheroidal grain. *No. 10888* is the *langli* of North Arakan, where it is employed for necklaces, and is for that purpose specially cultivated. It is identical with the Katha *kyeik-thi*. *No. 16049*, the *gyeit-thandu* from Akyab, is identical with the white

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COIX LACRYMA-JOBI. *var.* MONILIFER.

Katha grain. It is reported to be wild and to be largely used in that locality as necklaces by females. *No. 11561-A.* is a large straw-coloured grain that agrees with the preceding in most characters except in the light coloured shell and comparatively larger size. It comes from Tharawaddy.

Shán States.—*No. 12234*—This is a somewhat remarkable form received from Myelat in the Southern Shán States. It is there known as *kareik-lông* or round *kareik.* It is not edible and is a flattened spheroidal form, cultivated in Thamakan districts as a border plant around paddy-fields. It is used for ornamental purposes only: the mouth of the grain is often very large and gaping giving it an urceolate appearance. *No. 12235*—From the Eastern Division, Southern Shán States, there has been received an immense grain. It is a dark brown, polished flattened, spheroidal nut, with faint striations and is fully ½ an inch in diameter. It is said to be cultivated for food in the Kengtung Division of Mong Nai. This is the largest example of **Coix Lacryma-Jobi** in the entire Indian Museum Collection, while *No. 10889* (below) is the smallest.

TRANSITIONAL FORMS.

Transitional Forms.—The following are the transitional forms of **monilifer** passing either into **stenocarpa** or into the typical form **Lacryma-Jobi.**

(*A*) *Passing into the var.* **stenocarpa**:—

Burma:—*No. 11587.*—This came from Katha where it is known as *kyeik-thi.* It is never cultivated but used as an ornament by the Kachins. Capsular-spathe is very hard, of a steel grey or bluish white colour, blunt at both extremities, and about ¼ inch long with ⅙th of an inch in thickness. *No. 11803,* also from Katha, is a somewhat shorter grain, with a thick body and the mouth of the tube open and large. It is called *le-kyeik. No. 11585, kepaung* also, from Katha has a more elongated tube and merges into **stenocarpa.** It is stated to be wild and occasionally used for ornament by the Kachins. *No. 12163* is known as *gyeit koluma* in the Akyab District. It is a beautiful sample, with smooth regular grains tapering towards both extremities. It grows wild and is worn as necklaces by certain women. It is doubtless a form very near **stenocarpa.** *No. 10889* is a very small grain, about ⅛ inch in length, much like the preceding in shape, bluish white in colour. It is a polished hard grain with a distinct annular portion at the base. It is known in Arakan as *bewnu* and is cultivated to a small extent and used for necklaces. It is admirably suited for bead-making and would no doubt find a large sale if available in quantity.

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TRANSITIONAL FORMS.

(*B*)—*Passing into* C. Lacryma-Jobi *var.* typica :—

Burma :—*No. 10887.*—From North Arakan is sent as the only wild variety known in that district where it is called *borumpo.* It is used for purposes of ornamentation. This is so close to the typical Lacryma-Jobi that its position here is of doubtful merit. From Katha has also been received a black grain, *No. 11589A.*, very hard and highly polished, of a spheroid formation but slightly tapering towards the apex.

Shán States :—*No. 16050.*—From the Eastern Division, Shán States, is a pinkish straw-coloured grain. It merges into the Coix Lacryma-Jobi in shape, and I should place it under that form but for the fact of its colour. Grey, pink, brown, and black are colours more associated with monilifer than with the type.

COIX LACRYMA-JOBI *var.* MA-YUEN.

4th *var.* ma-yuen, *Stapf in Hook. f., Fl. Br. Ind. VII., 100; F. Romanet du Caillaud, Bull. Soc. Acclimat. (Ser. II.) VIII. (1881) 442-4;* C. AGRESTIS, *Steud. Syn. Gram. (1855), 9;* C. CHINENSIS, *Tod., Ind. Sem. Hort. Bot. Pan. (1861), 5; Balansa, Journ. de Bot. (Paris 1890), 77.*

Vernacular names.—*Bir-gaunli,* DARJEELING, BENG.; *dhan-gurgad,* SAMBALPUR, C. P.; *mriraku,* GARO HILLS; *kessi sikra, kessi kerenyessi, kessi teyahu, kessi kedyatha, kessi samaphe,* NÁGA HILLS; *sohriew, sohriew mynnar, sohriew reiwja,* KHASIA and JAINTIA HILLS, ASSAM; *gweik-win,* TAVOY; *taungya-kyeik, kachin-kyeik-pyu, kalinsi,* KATHA; *burum,* PROME; *sagyeik* ARAKAN; *geiksi, gyeiksi, gyeik-win,* or *gyeik-yin,* TENASSERIM; *kareik-kyé, kareikh-pyu, than-kareik,* MYELAT DIVISION; *kyeik-ya, kayeik-lon, sakyeik,* KARENNI DIVISION, SOUTHERN SHAN STATES; *kaleik-thi,* INTHU; *luthi, makauk-lae,* SHÁN; *beu* or *bo,* TAUNGTHU, BURMA; *ee-jin* or *ee-yin, y-dazi,* CHINESE; *bo-bo,* ANNAMITE of TONKIN.

Distribution.

Distribution.—In the Kew Herbarium there is a fairly extensive series of samples of this plant. The following may be accepted as denoting the chief peculiarities of these and the range of distribution of the plant :—***INDIA:*** ***Bengal*** Eastern, Griffith No. 6446 (grain white globose : this may be viewed as hardly different from monilifer); Sikkim, Herb. Ind. or. Hooker f. and T. Thomson, No. 1 (Coll. J. D. H.) cultivated and found at an alt. 2-4,000 feet (it has the fruits straw-coloured and the lower leaf sheaths often showing a tendency to harden as in the fruit-spathe; C. B. Clarke's No. 12383 (D.) collected in Darjeeling district; ***Assam*** : Khasia Hills—Herb. Hooker f. and T. Thomson, No. 1, collected in June 1850, said to be cultivated on the Khasia Hills alt. 4-5,000 feet (it has the grains chalky-white, globose and ribbed, also the stems and sheaths often bluish coloured). ***Burma,*** Mergui, Griffith, No. 6449: (this sample has leaves very long and the grain straw-coloured); Watt, (a grain almost spherical, white and furrowed, possibly a cultivated state of monilifer);

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COIX Spp.	Coix spp. or Job's Tears.

COIX LACRYMA-JOBI. *var.* MA-YUEN.

Distribution.

also from Southern Shán (*ex* Herb. Cal. 1895), (a cultivated plant with large grey-brown furrowed seeds). ***CHINA:*** Hong Kong—sample of grain yellow furrowed, sent as the *y-dzi* of Chinese and *bo-bo* of the Annamites: (this may be accepted as the type of Caillaud's Cochin China plant). ***MALAYA:*** Tonkin—B. Balansa, No. 4874 (named **C. chinensis,** Tod.) cultivated, a straw-coloured grain, deeply furrowed. Philippine Islands—Luzon Central, A. Loher (1866) (a straw-coloured grain, but almost smooth and fairly hard). N. Luzon No. 2007, said to be used as food by the Igorrotes of North West Luzon (grain very large, flattened, spheroidal, pinkish-white, leaf sheaths thickened, is probably only one of the large seeded cultivated forms of **monilifer** rather than **ma-yuen.** (I place it here with some hesitation). Saigon—Herb. L. Pierre No. 1938, (leaf sheaths thickened, grain elongated, brown, furrowed). Borneo: Mr. Motley, No. 1117, (characteristic straw-coloured and furrowed grain, but smooth and somewhat pointed). ***AMERICA:*** Demerara—this is a most curious specimen (collected by Mr. Parker), which has the leaf sheaths thickened into long tubes (a condition often seen in **ma-yuen**) is possessed of straw-coloured grains but the leaves show wart-like formations that bring to mind some of the examples of **C. gigantea,** in fact it may be a cultivated state of the plant.

In the British Museum Herbarium there are not many examples of this form that need be mentioned. The following are however of considerable interest. ***INDIA:*** Khasia hills—*ex* herb. Schlagintweit (at alt. 2,800 to 4,500 feet). ***MALAYA:*** Pierre's No. 1938 (a sheet slightly different from the corresponding one in Kew) a dark bluish fruited example with soft shell. ***CHINA:*** Dr. A. Henry's No. 2635 (A.) a pale straw-coloured grain, pointed and polished. ***EUROPE:*** the plant raised by Todaro (Hort. Bot. Pan. No. 918), apparently from seed procured from China, and to which he gave the name of **C. chinensis** (a name never apparently published), would seem to be this variety, although the sheet in Kew, which bears the varietal name of **globosa,** may be **monilifer.**

In the Edinburgh Herbarium will be found splendid series of specimens belonging to this variety. These represent the special collections recently made by the Reporter on Economic Products to the Government of India as well as some earlier sets. Some few years ago I collected **Coix** *var.* **Ma-yuen** in the Nága Hills (No. 6629) when I learned that the straw-coloured form was called *mung* and the steel-grey or black form was *kudhita thia* and the orange yellow grain *ke-see.* A sample (No. 9696A) procured by me from the Central Provinces carries this cultivated grain further into the

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interior of India than could be learned from the study of the Kew and British Museum Herbaria.

COIX LACRYMA-JOBI. *var.* MA-YUEN.

Description.

Description.—Popularly the series of plants referred to in this position might be described as the cultivated edible Job's tears. There are many well-marked forms or sub-varieties, the fruits of all of which are characterised by having a thin, loose, easily broken shell. They are often longitudinally striated and in many examples are constricted at the base into what has been spoken of as an annulus. There is a wide range in size and shape of the fruit-spathe, from almost spherical to pyriform. Some are so strong as to be hardly breakable between the fingers, others are almost quite soft. The striation is perhaps the most significant feature of the series though in sperical states the striation becomes indistinct. All are regularly cultivated, the hardness of the shell very possibly denoting recent or partial cultivation.

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The forms assigned to this position may be said to be referable to two distinct sections according to shape, colour and texture of spathe-shell :—

First section of Ma-yuen.

Section (A).—Spherical, fruit-spathe never bluish-white, an annular ring at the base usually present and longitudinal striation partially developed.

Sub-section.—Fruits, straw-coloured.

Bengal: Mr. A. C. Hartless sent *No. 14960* from Darjeeling. It is known as *bir gaunli.* Is evidently a very profusely growing plant with leaves one to two feet in length and a very soft loose shell not at all polished.

Assam: *No. 8818 (botanical specimen) and 8821 (seeds).*—This is the *mriraku* of the Gáro Hills. It is very hard and polished, is of a rich straw colour, and faintly furrowed, but has no trace of an annular basal portion. It is sown in March-April, and ripens in November and December. It is roasted by being placed over the fire and then husked. It is both eaten as a grain and used to produce the Gáro fermented drink. *No. 10601 (and bot. sample No. 10210).*—This is the *kessisikra* of the Nága Hills. One of the commonest cultivated forms and very like the Darjeeling sample having, however, longitudinal furrows more distinct. It is believed that the Trans-Dikhu Nágas as also Sema Nágas live very nearly entirely on this and one or two other closely allied forms of Coix. There is no rainy season crop. It is sown in May and reaped in November and December. The crop is raised on *júm** lands never on submerged paddy lands—in fact it may be said to be raised on land

* *Júm* is nomadic hill cultivation implying the burning of a patch of forest, and its abandonment after cropping for 2 or 3 years. Conf. *taungya*, p. 222.

COIX Spp.

Coix spp. or Job's Tears.

COIX LACRYMA-JOBI var. MA-YUEN.

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too high and too dry for rice. It is, moreover, believed to exhaust the soil much less than rice. The rotation is usually Job's tears first year after cleaning, followed by rice next year and a fallow of five years thereafter. A plot of land, say, 18 × 20 feet, would yield from 10 to 30 seers according to the value of the soil. This particular form of Coix is rarely made into *atta* (or flour) but is eaten whole like rice and is always sown mixed with *kessiteyahu* (No. 10212). The *dzu* beer made from these separately or mixed is the cheapest quality but it turns sour after 10 or 12 days.

Nagas have a rotation into which Coix enters.

Conf. pp. 221, 225.

Burma.—*No. 11732.*—From Amherst has been received a small spherical form of a straw-colour. It is said to be used as a side-dish, not as a staple of food and resembles glutinous rice. It grows where-ever paddy (rice) will grow.

Sub-section—Fruit chalky-white.

Burma.—*No. 10944*—Mergui and Tavoy. Coix is said to be sown mixed with paddy and reaped at the same time. It is a fairly important crop with the Karens and a certain amount is exported to Penang. There are reported to be two kinds, a white and a black. The unhusked seed sells at R1 per basket and the husked and pounded grain at R4-8 per basket. It is known as *gweik-win*. The white sample alluded to is often very hard, faintly striated longitudinally and is sometimes prolonged into a fairly well-formed beak as in C. aquatica. *No. 11581*—from Tenasserim is a very similar, though considerably smaller, form and more spherical in shape. It is said to be called *geiksi*. *No. 13790* is an exactly similar white striated grain, from Katha known as *kachin-kyeikpu*.

Assam.—*No. 8200*—From the Khasia Hills has come a spherical white striated grain, called *sohriew mynnar* or *sohriew*. It is very nearly identical with the Kátha grain. It is said to be sown in April and May and harvested in December. Occasionally it is alternated with potatoes. The grain is husked, then ground in a mill, and eaten as food by the Khasias. It sells at R2 per maund. A second consignment (*No. 11674*) was received along with botanical samples. The grains of this consignment (said to be identical with the former supply) are much less striated possibly because not so ripe. *No. 8201*—also from the Khasia Hills, received under the name of *sohriew reiwja*, cannot be separated from *No. 8200* already discussed.

Second section of Ma-yuen.

Section (B).—Pyriform grains with a short basal annulus and strongly striated.

Sub-section—Straw-coloured or parti-coloured.

Bengal.—Mr. C. B. Clarke collected this plant in August 1870 in the Darjeeling District at an altitude of 4,000 feet, but he furnishes no information as to whether it was found under cultivation or on

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abandoned *júm* land. The fruit is small, pyriform, straw-coloured and rather polished.

Assam.—*No. 10212.*—This is the *teyahu-Coix* (or *kessi*) of the Nága Hills. It is doubtfully distinct from *No. 10210*, except that it is more pyriform and with the base of the fruit of a darker colour. The two are often grown mixed. A third form (*No. 10211*) is called *kessi kedyatha.* This I am unable to separate from *No. 10212.* They are not ground into *atta* but are eaten like.

Central Provinces.—*No. 9696,* the *dhán gurgad*, is a pyriform straw-coloured form grown at Sambalpur to an extent of perhaps 100 acres and recognised as the best local variety. It is used as an article of food by the aboriginal tribes. The fruit is shelled and the grain reduced to a kind of meal or flour. Water is then added and the cakes cooked on the fire in the usual way. Occasionally it is mixed with the flour of some cereals such as wheat, or millets. At times a sort of gruel is prepared from the grain. The unhusked seed is sold at 2 to 3 annas a seer.

Burma.—*No. 10886*, from Prome, is a very similar grain only a little more distinctly striated than the Sambalpur form. It is said to be known as *burum* and is stated to be the only kind used as food in North Arakan. It is the common edible form of Burma. *No. 11590*, from Katha, is a small pyriform grain, straw-coloured above, dark-brown below. It is called *kalinsi* and is used for food similar to rice. It is grown along with *taungya*-paddy (*i.e.*, on *júm* land). *No. 10891*, from Arakan, is a similar, though more elongated, grain and with a very distinct annulus, it is of a dull bluish grey colour. It is there known as *Sagyeik.*

Shan States.—*No. 12232*, from the Myelat Division of the Southern Shán States, a small white grain has been received. It is pyriform, has a fairly distinct annulus and is prominently striated. It is called *kareik hpyu* (or white *kareik*). *Kareik*, also pronounced *kaleit*, is the generic name for Coix. It is a winter crop, cultivated and used by nearly half the population of the Myelat Division.

Sub-Section.—Bluish-black colour, strongly striated and with a pronounced annular process.

Assam.—*No. 10213*, the *kessi kerenyessi* and *No. 10214*, the *kessi samaphe*: these two forms have come from the Nága Hills. They are both of them large, dark-bluish grains, pyriform, deeply striated, and with a very distinct annulus. The former is a larger and paler coloured grain than the latter. They are both said to be specially suited for the preparation of *atta* (flour) and the manufacture of *dzu* beer. The *kessi kerenyessi* is specially prized for

Conf. with pp. 220, 225.

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Coix spp. or Job's Tears.

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its beer, which will keep about 3 months in the cold weather and is also said to be stronger than the beer from any other kind.

Burma.—*Nos. 10893* and *11802* are very much like the preceding. They come from Prome. *No. 11560*, a smaller grain from Tharawaddy: it is a small bluish form strongly striated. *No. 10945*, from Tavoy District, Tenasserim, is a very dark-blue form and has received the vernacular name of *gyeik-yin*. The basal annulus in this case is scarcely distinct. *Nos. 10882* and *10884*, from Akyab. They are lighter coloured grains than most of the others in this subsection. *No. 10882A* is an extraordinary form received also from Akyab. It is a longish bent grain with a very strong annulus and of a dark bluish brown colour. *No. 11806*, from Katha. Is a large coarsely formed grain with a strong annulus and also of a dark bluish brown colour. It appears to be known as *taungya-kyeik*. *No. 11582*, an exceedingly black striated grain, has come from Tenasserim, where it is called *geik-si*. The grain is very hard and polished. *No. 11732-1*, from Amherst, was received along with the straw-coloured form already described. It is a dark brown-black grain, scarcely striated, very hard and polished, and looks as if only partially cultivated. It is the hardest shelled grain of all the long series of forms, which I have placed under the variety **Ma-yuen.** *No. 13788*, from Thaton District, was sent as an odorous and edible variety of that locality; it is identical with the sample from Amherst described above.

Shán States.—*No. 12238* has been received from the Eastern Division, Southern Shán States. It is known under the following vernacular names:—*sakyeik* in Burmese, *makauk-lwe* in Shán and *beu* or *bo* in Taungthu. It is cultivated as a food grain in Mongsit, Mong Pawn, and Mawkmi, and is stated to be common everywhere throughout the division. It is a small form dark brown or black in colour and with a pronounced annulus. *Nos. 12230 & 12231*, blue forms of the edible **Coix**, are the *kareik-kyi* or *than-kareik* obtained from the Myelat Division of the Southern Shan States. They are very similar to the Akyab grain described above. These are sown with *taungya** (dry) paddy in May and June, and are reaped in November and December. They are occasionally grown with Indian corn, and are eaten either boiled with rice or separately. They are used by all the tribes inhabiting Myelat. *No. 12231* is a slightly smaller grain with the ridges of the striation of a lighter blue colour than the furrows. *No. 12239*, also a blue striated grain, came from the Eastern

* Taungya—a patch of forest land cleared and put under cultivation; from *taung*, a hill, and *ya*, dry cultivated land as contrasted with ordinary paddy land or land liable to floods. Conf. *jum* land, p. 219.—ED.

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Division, Southern Shán States. It is called *bohpreing*, and was placed in a consignment spoken of as wild. This is apparently a mistake. *No. 15060* from the Karenni Division, of the Southern Shán States, is a very striking plant. It is profusely flowering and fruiting, and has very short broad leaves and large blue striated nuts. It is known by several names of which the following are the most important:—*kyeik-ya, kyeik-lon, sakyeik, luthi*, in Burmese; *kaleik-thi* in Inthu; *makauk-lwe* in Shán; *kabuse* in the Red Karen Country, and *beu* in the White Karen Country. It is said to be sown in Jeun and reaped in October. **COIX LACRYMA-JOBI *var.* MA-YUEN.** **Review of Indian Collections.**

Food.—This curious grain might almost be said to be unknown to the inhabitants of India generally, except as a weed of cultivation. To many of the aboriginal tribes, however, such as those of the Central Provinces, Sikkim, Assam and Burma, it is an important article of food. The plant grown as a regular field crop, is invariably one or other of the many forms of the variety **Ma-yuen** already fully detailed. But in times of scarcity the wild forms of these plants are (all over India) resorted to as articles of food. The grain is held to be sweet and wholesome, the only objections to it being the smallness of the supply and the hardness of the shell. In the forms specially cultivated for food the shell is soft and amenable to ordinary methods of milling. **USE AS A GRAIN.**

Roxburgh was apparently unware that **Coix** had to be included among the edible cereals of India, though doubtless he had read Rumphius' description (1750) of its cultivation in the Islands of the Malays, and Loureiro's account of it in Cochin-China. In the Agri-Horticultural Society of India's Transactions for 1841 (*VIII, p. 348*) mention is made of the grain being sent from Amherst. Mr. Riley, who presented the sample, said "the plant was of a very hardy nature and thrives upon almost any kind of soil yielding a good amount of produce and in taste resembling wheat." Wallich identified the plant as **Coix lacryma.** Sir J. D. Hooker, in his Himálayan Journals (1848), gives some interesting particulars regarding its cultivation in the Khasia Hills. "Each plant," he tells us, "branches two or three times from the base and from 7 to 9 plants grow in each square yard of soil; the produce is small, not above 30 to 40 fold." Mason in his "Burma and its People," (1860) published much useful information and this has been brought up to date in the new edition by Theobald (1883). We there read that "**Coix** affords a good example of the results of cultivation of a wild plant, the seed of which is of a stony hardness, but which is soft in the cultivated form and the kernel sweet. It is much cultivated by the Red Karens and may be often seen for sale parched in the bazaars."

COIX Spp.

Coix spp. or Job's Tears.

FOOD. USE AS A GRAIN.

In the review above, of the collections recently furnished to the Reporter on Economic Products from very nearly every important locality of India, I have quoted, under the special forms, the practical observations of the local authorities. This course was deemed preferable to a compilation of data into a common paragraph on cultivation, of facts and opinions that would seem in many cases only applicable to the individual forms of the plant. It may therefore be accepted as undesirable to republish that information in order to support the statement that there exists in India a fairly extensive and certainly a widely dispersed cultivation of the plant. There are great diversities in size, shape and colour of the grain, as also in the quality and the purpose to which put. These diversities, confirmed by the existence of many vernacular names, establish belief in an ancient knowledge as possessed by the aboriginal tribes of India. It has already been affirmed that very possibly the pastoral Aryan invaders grew this grain on the slopes of the Himálaya, very possibly anterior to their becoming localised and assuming cultivation as a craft.

Dispersal through India

If that view be correct, its systematic production has entirely disappeared from the Himálaya except in Sikkim : on the plains and lower hills of India it is now met with in the Central Provinces and the adjoining mountainous tracts of Bengal only. But from Darjeeling and through Bhután to the Mountains of Upper and Eastern Assam, the Khasia and Gáro Hills and the Nága Hills, etc., to Burma and the Shán States, **Coix** might be described as not only a fairly plentiful crop but an exceedingly important article of diet. The perusal of the foregoing observations on the forms of the plant may be accepted as having brought out the somewhat surprising circumstance that certain forms of the grain are roasted, then husked and eaten whole, being either parched (as with Indian corn) or boiled as with rice. Other forms are so very different that the grain may be milled and ground to flour (*atta*) and thereafter baked into bread. It seems probable that the properties that necessitate so very different methods of treatment and preparation, involve a diversity chemically and structurally quite as great as that which exists between the hard and the soft wheats or the glutinous and the starchy rices.

Story of its introduction to China.

Romanet du Caillaud (*Bull. Soc. Acclimat Ser. II., 1881, Vol. VIII, pp. 442-4*) tells us that in the 1st Century A.D. the **Chinese General Ma-yuen** conquered Tonkin and became so fond of the Annamite grain *bo-bo* (the *y-dzi* of the Chinese) that he carried away several cart-loads of seed and thus introduced its cultivation into China. **Bretschneider** (*Botan. Sinicum, Pt. III, 1895, p. 384*) says of **Coix** that it is cultivated near Peking under the name *ts'ao sz'r.* He then adds that there are two varieties one with white, the

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other with grey coverings to the fruits. "I have also observed," he adds, "in the druggists' shops a variety (or species) with small oblong pointed fruits." This oblong pointed fruit might be C. gigantea, and, if so, it would be most interesting to find that species in China. Many writers have given their opinions on the Coix grain of China. It is often spoken of as the *Ee-jin* or *Ee-yin* and is reputed to be one of the most remarkable of foods. Dr. Smith wrote that it is larger and coarser than pearl barley but equally good for making gruel. FOOD. USE AS A GRAIN.

In a small book on the Useful Plants of Japan (issued by the Agricultural Society of the country) it is called the *tomagi* or *hatomagi*. "It is an annual cereal grass cultivated in common dry land. The stalks grow to a height of 4-5 feet. The grain pounded in a mortar and cleaned is consumed as meal and *mochi*. An infusion of the parched and ground grain is used instead of tea and is called *kosen*. A Chinese variety of larger grains, greyish brown in colour, with thinner shells is more easily crushed and cleaned." A gruel of the flour is specially commended by Romanet for use in hospitals. The Chinese use the grain in soup, as pearl barley is employed in Europe. In Japan.

Manufacture of beer.—The references to the Japanese habit of drinking a decoction of the grain and to the preparation of gruel and tea from it, necessarily suggests the more extended use in the manufacture of a kind of malted beer which in the Nága hills is called *dzu*. But a surprising feature may be said to be the circumstance that the *dzu* made from one grain is of a much superior flavour to that from another, and further that the *dzu* of one grain may be kept for months, while that from another goes bad in a few weeks. I have personally experienced much pleasure while travelling in the Nága Hills in drinking fresh *dzu*. It is something in flavour between that of butter-milk and cider, and on a hot day at the termination of a long march is most acceptable. Some of the forms of Coix (like many rices) have a rich perfume and such grains when used in the preparation of beer are said to give it a fruity flavour and delicate aroma. BEVERAGES PREPARED FROM COIX. *Conf. pp. 220, 221.*

Medicinal properties.—A Missionary, writing of Tonkin to M. Romanet du Caillaud, said that Job's tears made a refreshing drink, was a good blood purifier and excellent diuretic. The gruel prepared from the ground seed he observed as also *Eau de Larme-de-Job* was extensively employed in the summer to cool the body. By the Tonkin people it is spoken of as the "grass of life and health" is believed to neutralise the miasma of the air and to purify water when boiled like tea with a small quantity of Coix flour and set by MEDICINE.

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COIX Spp.

Coix spp. or Job's Tears.

MEDICINE.

to cool before being used In India **Coix** can hardly be said to enjoy any reputation for medicinal virtues. The **Rev. Dr. Campbell** tells us that among the Santals the root is given in strangury and in the menstrual complaint known as *silka*. **Dymock**, (*Veg. Mat. Med.*) says the seeds are sold in the drug shops of Bombay under the name of *kassai bij*. The *Pharmacographia Indica* says that the wild form only is used medicinally and that it is considered strengthening and diuretic.

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Chemical properties.—The grain of **Coix** both wild and cultivated has been subjected to chemical tests and the somewhat conflicting results that have been published doubtless are due to the botanical position of the particular plant under examination, not having been previously ascertained. In **Professor A. H. Church's** *Food Grains of India* (*published 1886, p. 60*) occurs the following remarks: "In the sample of this grain which gave the above analytical figures it was found that the edible seed after the removal of the hard and shining grey husk did not weigh more than 1 for every 4 parts by weight of the whole grain operated upon." In the *Kew Bulletin* (*for 1888, p. 59*) is published **Professor Church's** second examination and this a specimen admittedly of the cultivated grain. "From four parts by weight of the sample," he says, "three parts of husked grain were obtained—three times the quantity yielded by **C. lachryma**" (presumably the comparison drawn, is to the sample reported on in *The Food Grains* which was probably a wild grain). Subsequently **Professor Church** gave his third analysis in the *Supplement to the Food Grains* (*1901, p. 3*) the grain examined having been the cultivated **Coix** of the Khasia hills. The following sets forth the practical results of the first and third of these examinations:—

	Nutrient Ratio.	Nutrient Value.
Wild Coix	1 : 3·8	89
Cultivated Khasia Hills	1 : 4·4	90

Commenting on his final results **Professor Church** says that the quantity of albuminoids approaches to that of some kinds of pulse and that the proportion of oil or fat is larger than that present in the great majority of cereals. The following detailed analysis gives the composition of the grain in 100 parts, as published by **Professor Church** and subsequently by the Haarlem Museum authorities, by **Mr. Hooper**

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of the Indian Museum Report and by **Drs. Paton** and **Dunlop** in *The Agricultural Ledger* No. 6 of 1904, page 50.

	Professor Church.		Haarlem Museum, 1901 (cultivated grain).	Indian Museum, 1901-02 (cultivated grain).	Paton and Dunlop, 1904 (wild plant).
	1886 (wild plant).	1901 (cultivated grain).			
Water . .	13·2	14·8	13·91	8·00	10·74
Albuminoids .	18·7	16·6 *	21·72†	22·46	18·81
Starch . .	58·3	60·1	55·29	61·82	59·55
Oil . . .	5·2	5·8	1·30	4·92	6·2
Fibre . .	1·5	0·9	1·48	·70	1·28
Ash . .	2·1	1·8	1·79	2·10	3·4

* 2·66 nitrogen. † 3·47 nitrogen.

In *The Agricultural Ledger* No. 7 of 1903, p. 150, **Dr. Leather** gives the results of the examination of **Coix** which differ in the small amount of albuminoids that he found (9·44) due undoubtedly to the shell being included. **Dr. Leather** expresses the total nitrogen found at 1·58 and the albuminoid nitrogen as 1·51.

Paton and **Dunlop** were specially investigating certain famine foods. The form of **Coix** they examined was therefore a wild grain and may have been **Coix Lacryma-Jobi**, but possibly it was **Coix gigantea.** They remark:—"Our analyses as well as those of **Dr. Church** show that this is a food specially rich in proteids and fats. When separated from its very hard husk it should form a food of great value, especially as its energy-value is the highest of all the foods studied."

INDUSTRIAL AND DOMESTIC USES.

Industrial and Domestic uses.—From a remote antiquity both in Europe and in India, the grains or seeds, especially of the wild plant, have been used as the beads of rosaries. By the aboriginal tribes of India and Burma they are largely employed in personal adornment. Necklaces, ear-rings, head-dresses, etc., are often largely composed of them, and dresses, bags, baskets, etc., extensively ornamented with them. For these purposes a semi-cultivation has been pursued, possibly for centuries, that has resulted in the development of special grains, in cylindrical or spheroidal forms and in a rich variety of colours. In Nepál, Oudh and among the hill tribes of the central tableland of India generally, they are employed either by themselves or in conjunction with cowrie-shells, in the decoration of baskets, agricultural implements and cattle. By the Karens of Burma the cylindrical grains cover certain portions of dress and are

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INDUSTRIAL AND DOMESTIC USES.

elaborated in designs that simulate (or perhaps may have suggested) some of the patterns seen in embroidery. With the Angami Nágas, ear-rings are constructed that consist of a rosette of the elongated seed surrounding the metallic green wing-cases of a beetle.

The possibility of a profitable expansion of the industrial uses of these seeds, to a large extent suggested the inquiry, the history of which and many of the practical results of which, have already been fully set forth. A fairly large trade exists in the use of these seeds, as for example the construction of the Japanese bead door-curtains. Mention has been made (under **C. aquatica**) of an exceptionally large seed discovered by me in Poona and there made into one of these curtains. It seems probable that **C. gigantea** and **C. aquatica** together with some of the larger forms of **monilifer** are most likely to be utilized in that manner. But in discussing possible future industrial developments it is essential that the separation indicated into the forms of **Coix Lacryma-Jobi** that are cultivated and those that are wild, should be clearly kept in mind. Cultivation destroys very rapidly the hard pearly shell, upon which to a very large extent the industrial demand depends. It also changes the colour of the grain and produces dull chalky whites and straw colours, utterly devoid of the rich glossiness of the wild grains. By the selection and partial cultivation of spontaneous varietal forms or sports (such as those named **stenocarpa** and **monilifer**) these dangers are ever present. This fact is fully appreciated by the Burmese experts and the cultivation, partial though it be, is abandoned for a time or fresh stock secured from the jungles, when degeneration is observed. In the series on my table there are exceptionally long forms of **stenocarpa**, with soft striated straw-coloured shells, quite useless as natural beads, just as the transition is also demonstrated from **monilifer** to **stenocarpa** on the one side and to **Ma-yuen** on the other. It is thus difficult, if not impossible, to guarantee a continuous supply of any one shape, size or colour of grain, and this may at once be admitted as (from the European point of view) a serious obstacle to a greatly increased demand. The smaller and more gracefully formed examples of **monilifer** and of **stenocarpa** it would seem stand in fair chance of coming into use in Europe as beads especially in the construction of bugle-trimmings and as buds and other special portions of artificial flowers. They would be cheaper, more durable than the glass at present used, and since they may be dyed any desired shade of colour, they might be extensively used in dress trimmings. The difficulty of producing and maintaining certain sizes and shapes of grain would doubtless soon be overcome, were a profitable demand to arise for a larger production than at present exists.

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Coix spp. or Job's Tears.

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CHEMISTRY.

Further analyses by Mr. D. Hooper.

[The following six analyses, with the exception of the first, have not been seen by Sir George Watt. They were received as the above papers were passing through the press.—Ed.]

No. 1. **Coix gigantea,** *Roxb.* from Dehra Dun, 8599 (see p. 197) 100 parts of seed gave 26 kernel and 74 shell.

No. 2. **Coix gigantea,** *Roxb.* **var. aquatica,** *Watt.* Mandla, C. P., 8768 (see p. 201) 100 parts of seed gave 32 kernel and 68 shell.

No. 3. **Coix Lacryma-Jobi var. Ma-yuen.** *Stapf.* Chalky (see p. 220) white form, Khasia Hills, 8201. 100 parts of seed gave 37·5 kernel and 62·5 shell.

	1	2	3
Kernel—			
Water	8·00	8·00	9·60
Oil	4·92	5·56	5·70
Albuminoids	22·46	18·75	17·46
Carbohydrates	61·82	64·16	64·58
Fibre	·70	·83	1·00
Ash	2·10	2·70	1·66
	100·00	100·00	100·00
Shell—			
Water	5·80	11·00	7·80
Oil	1·00	1·15	3·30
Albuminoids	12·50	6·25	7·21
Carbohydrates	26·10	8·60	27·93
Fibre	34·00	38·35	40·00
Ash	20·60	34·65	13·76
	100·00	100·00	100·00

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